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**CASIO RESERVOIR**

FROM SUNRISE TO SUNSET  
HIKING & SHORE FISHING

**MOTORIZED VEHICLES  
BEYOND THIS POINT**

IN MUNICIPAL WATER DISTRICT

California  
Resources Agency

Department of  
Resources

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# Impact of Severe Drought in Fresno County, California

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# Impact of Severe Drought in Marin County, California

Bulletin 206  
November 1979



On the Cover Sources of Marin Municipal Water District's supply had depleted to such critical stages during the drought that the District was compelled to implement various rationing programs. Here Nicasio Reservoir, a major source of MMWD's supply, is shown extremely depleted.

**Department of  
Water Resources**

**Bulletin 206**

# **Impact of Severe Drought in Marin County, California**

**November 1979**

**Huey D. Johnson**  
Secretary for Resources

**The Resources  
Agency**

**Edmund G. Brown Jr.**  
Governor

**State of  
California**

**Ronald B. Robie**  
Director

**Department of  
Water Resources**





## FOREWORD

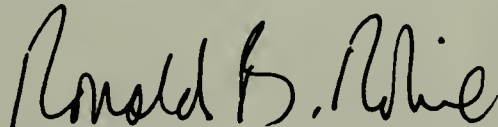
The California drought of 1976 and 1977 hit Marin County early and hard. Marin County depends largely on local streams and rainfall for its water supplies, so when precipitation dropped to 55 percent of normal in 1976 and 48 percent of normal in 1977 the County's 220,000 residents were faced with shorter water supplies than almost any other community in the State.

In 1976, dairy and livestock ranchers experienced high production costs, lawns withered and some home and apartment owners contracted to have water hauled in to save greenery, and communities on the County's coast drew statewide attention as their water supplies reached the critical stage.

In 1977, the water shortage in Marin County attracted national attention as reservoirs almost dried up and water rationing became mandatory. Private citizens, businesses, and government agencies at all levels employed myriad and diverse ways of coping with the crisis.

The situation in Marin prompted the Department of Water Resources to take an in-depth look at the drought's effects there. Knowing what happened in Marin County could help other areas faced with similar problems. In the summer of 1976, the Department began a study (1) to assess the response of the citizens of Marin County to the water conservation and rationing restrictions under which they were living as well as the effectiveness of those restrictions and (2) to determine the incidence and extent of drought-related economic and social costs and losses.

This bulletin summarizes the results of that study and concludes by discussing the aftermath of the drought, particularly a number of tough issues that were raised by the severe water shortage. Detailed analyses of the data have been compiled in an appendix which is available upon request.



Ronald B. Robie, Director  
Department of Water Resources  
The Resources Agency  
State of California





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\*This study was initiated by the Resource Evaluation Office under the direction of G. Donald Meixner, Supervising Engineer, Water Resources. The Resource Evaluation Office was subsequently incorporated into the Division of Planning.

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## CONVERSION FACTORS

### Metric to Customary System of Measurement

<u>Quantity</u>	<u>Metric Unit</u>	<u>Multiply by</u>	<u>To get customary equivalent</u>
Length	millimetres (mm)	0.03937	inches (in)
	centimetres (cm) for snow depth	0.3937	inches (in)
	metres (m)	3.2808	feet (ft)
	kilometres (km)	0.62139	miles (mi)
Area	square millimetres (mm <sup>2</sup> )	0.00155	square inches (in <sup>2</sup> )
	square metres (m <sup>2</sup> )	10.764	square feet (ft <sup>2</sup> )
	hectares (ha)	2.4710	acres (ac)
	square kilometres (km <sup>2</sup> )	0.3861	square miles (mi <sup>2</sup> )
Volume	litres (l)	0.26417	gallons (gal)
	megalitres	0.26417	million gallons (10 <sup>6</sup> gal)
	cubic metres (m <sup>3</sup> )	35.315	cubic feet (ft <sup>3</sup> )
	cubic metres (m <sup>3</sup> )	1.308	cubic yards (yd <sup>3</sup> )
	cubic metres (m <sup>3</sup> )	0.0008107	acre-feet (ac-ft)
	cubic dekametres (dam <sup>3</sup> )	0.8107	acre-feet (ac-ft)
	cubic hectometres (hm <sup>3</sup> )	0.8107	thousands of acre-feet
	cubic kilometres (km <sup>3</sup> )	0.8107	millions of acre-feet
Flow	cubic metres per second (m <sup>3</sup> /s)	35.315	cubic feet per second (ft <sup>3</sup> /s)
	litres per minute (l/min)	0.26417	gallons per minute (gal/min)
	litres per day (l/day)	0.26417	gallons per day (gal/day)
	megalitres per day (MI/day)	0.26417	million gallons per day (mgd)
	cubic metres per day (m <sup>3</sup> /day)	0.0008107	acre-feet per day
Mass	kilograms (kg)	2.2046	pounds (lb)
	tonne (t)	1.1023	tons (short, 2,000 lb)
Velocity	metres per second (m/s)	3.2808	feet per second (ft/s)
Power	kilowatts (kW)	1.3405	horsepower (hp)
Pressure	kilopascals (kPa)	0.145054	pounds per square inch (psi)
	kilopascals (kPa)	0.33456	feet head of water
Specific capacity	litres per minute per metre drawdown	0.08052	gallons per minute per foot drawdown
Concentration	milligrams per litre (mg/l)	1.0	parts per million
Electrical conductivity	microsiemens per centimetre (μS/cm)	1.0	micromho per centimetre
Temperature	degrees Celsius (°C)	(1.8 × °C) + 32	degree Fahrenheit (°F)



NORTH MARIN COUNTY WATER DISTRICT



MARIN MUNICIPAL WATER DISTRICT

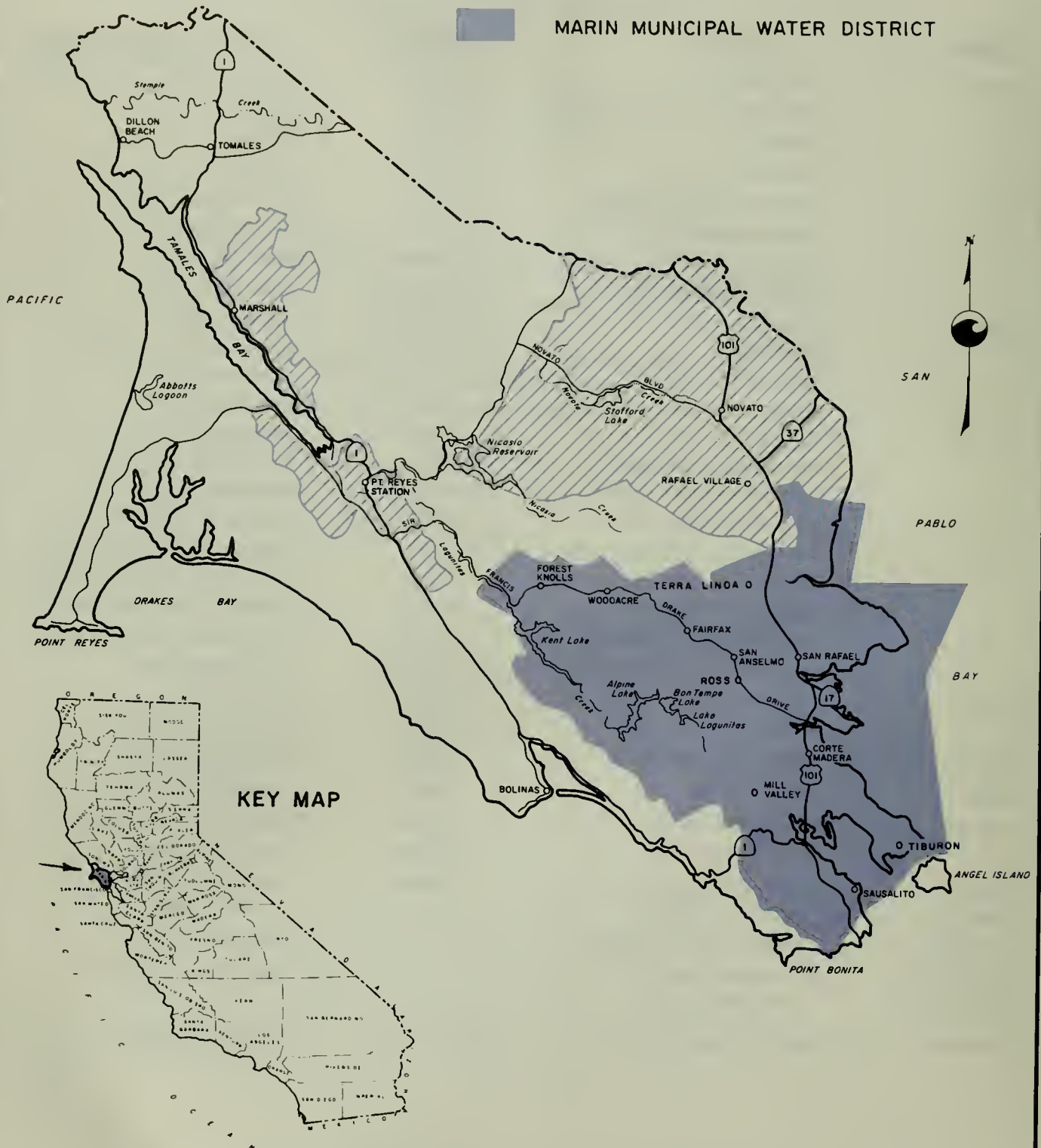


Figure I. MARIN COUNTY WITH MAJOR CITIES AND WATER DISTRICTS

## CHAPTER 1. INTRODUCTION

Water conservation took on a special meaning throughout California in 1976 and 1977. Faced with critical water shortages, many areas adopted water conservation programs, and in some communities -- such as Marin County -- mandatory rationing was imposed as early as February 1976. Marin County, where 1975-1976 rainfall brought only 45 percent of normal reservoir storage, provided an excellent opportunity for observing a community's response to severe drought.

In the summer of 1976, the Department of Water Resources (DWR) began studying the effects of the water shortage in Marin County. Although the county had experienced minor dry periods in recent times, 1976 ushered in the first major drought in some 30 or more years. The lessons learned will have important application when drought recurs in the future.

In February and March 1977, DWR surveyed water users within the Marin Municipal Water District (MMWD) and all nurseries and livestock ranchers throughout the county. The investigation focused on MMWD because the majority of the county's population resides in its service area and it provided the most representative sample of urban water users in the county (see Figure 1). The timing of the survey and the bulk of the data collected reflect the experiences of the first year of drought (1976) and initial reactions and expectations for the second, more severe year of drought.

The survey was accomplished by mail questionnaires and personal interviews. Questionnaires were sent to a randomly selected 20 percent of the urban water users in MMWD and all of the nurseries and livestock ranchers in Marin County. Personal interviews were conducted with administrative personnel from selected

cities, schools, and other public agencies.

The principal objectives of the survey were to:

1. Document MMWD's experience and techniques for handling the drought, so other districts could learn from them.
2. Gather data that would help MMWD and county officials shape drought policies and programs.
3. Describe the rationing and conservation measures adopted by MMWD, when they were implemented, and when they were altered or discontinued.
4. Determine who used water from sources other than MMWD.
5. Identify the various conservation measures and techniques adopted by individual users and find out which ones were most popular.
6. Measure the effects of water conservation on outdoor landscaping.
7. Determine the benefits accrued and the costs and losses suffered by the people of Marin County due to the drought.
8. See how effective the water use restrictions and conservation measures employed in Marin County were for different categories of water users.
9. Document the costs and losses sustained by livestock farmers, assess their available supplies, and identify the measures they used to supplement their dwindling water resources.

The format of this report follows these objectives in general sequence. The key

findings are presented in Chapter 2 and the measures taken to combat the drought reported in Chapter 3. The effects of

the drought on residences, businesses, and livestock ranchers are reviewed in Chapters 4, 5, and 6, and the aftermath of the drought is reported in Chapter 7.



## CHAPTER 2. FINDINGS

The major finding of this bulletin is that a community can accommodate even prolonged and intense drought conditions. The 1976-77 plight of Marin County residents has shown that, regardless of water-using habits acquired during times of plenty, great sacrifices in convenience and comfort can be made by community members when the reality of severe water shortage is impressed upon them.

The ability of individuals to creatively and efficiently cope with water shortage is unquestionable in light of Marin County's drought experience. However, another finding of this bulletin concerns the means by which community members become convinced that their drought is indeed serious enough to warrant sacrifices such as Marin County residents made in 1976-77. Here, this study observes that as drought worsened, the citizens of Marin County responded by conserving increasing amounts of water. Consumption by MMWD customers equalled the District's 1976 rationing schedule and met and exceeded the considerably tougher rationing schedule in 1977. The community became convinced of the seriousness of the drought through public awareness programs, public meetings, the media, and the reality of increasingly stringent water conservation and rationing measures.

Water supply policy conclusions can be drawn considering the facts in this bulletin. Generally, these conclusions can be summarized as a situation where increasingly severe water supply conditions must be mitigated by increasingly severe supply policies. Such policies may include the following as adopted by MMWD: bans on various water uses, rationing allotments, and strict water pricing schedules.

In addition to water conservation and rationing, MMWD managers had to work swiftly and locate alternative sources of water to augment dwindling supplies. Use of reclaimed water and a temporary pipeline bringing water across the Richmond-San Rafael Bridge were welcome additions to reservoirs and lakes that were quickly going dry.

The media played an important role during the drought by explaining to the public the nature of the drought and the conservation measures that had to be taken. MMWD would have had a difficult time justifying its drought tactics all by itself. This mutual reinforcement of the drought message helped considerably in raising the community's drought consciousness. The media promoted water



*A sign above the Marin Municipal Water District's offices kept water users informed on how well their water conservation efforts were progressing.*

conservation in various ways. For example, the *Independent Journal* offered \$25 for ingenious water-saving ideas and then publicized them in the paper.

In 1976, MMWD customers cut back their normal water consumption by 25 percent in accordance with a district-wide rationing program. In 1977, MMWD customers decreased their consumption by 63 percent, 6 percent more than the 57 percent reduction that was then mandated. A reduction of this magnitude required a lot of good will, ingenuity, and sacrifices by most everyone in Marin County. The most important specific findings of the study are listed below in the three categories of water users that were surveyed: residences, businesses, and livestock ranchers.

### Residences

Data on residential water consumption is presented for single-family dwellings and multiple-family dwellings (duplexes and apartments). Town houses and condominiums were excluded from consumption analysis because of incomplete data. The year 1975 had a near-normal rainfall and is used as a normal water use period for comparison (see Table 1).

- ° Community members continually re-appraised and modified their outdoor watering practices throughout the drought. As drought worsened and landscapes were increasingly threatened, community members exhibited increasing willingness to expend time, energy, and money to avoid landscape losses.
- ° The most "practical and effective indoor water-saving measures" reported by respondents to DWR's survey were those used in the bathroom. Among those measures were less frequent toilet flushing and reduction in frequency of showers and baths.
- ° Community members were actively adopting water conservation practices throughout the drought.

However, the fact that most measures and restrictions occurred after rationing measures were instituted suggests the possibility that active indoor as well as outdoor conservation practices may need rather strong incentives for implementation.

- ° Community sentiments on controversial drought policy issues appear to be equally split between pro and con factions. Thus, developing a drought policy is at best a "tightrope walking" situation in that policy makers may have difficulty finding solutions that please a majority of their constituents.
- ° Residential water consumption was found to be affected by (1) climate, (2) the number of people in a household and income-related items, such as the portion of lot requiring water, and (3) the number of water-using appliances and swimming pools.

Table 1. AVERAGE DAILY PER CAPITA CONSUMPTION IN LITRES (AND GALLONS)

Water User Type	1975	1976	1977
Single Family Dwelling	462 (122)	334 (88)	132 (35)
Multiple Family Dwelling	275 (72)	242 (64)	125 (33)

### Businesses

The questionnaire to businesses applied to a wide spectrum of business and community services -- all nonresidential metered customers of MMWD. Approximately 7 percent of MMWD customers fall within this broad category, accounting for 28 percent of the District's metered consumption. Of the 730 businesses that were surveyed, 211 responded.

- ° Many businesses could not meet the 57 percent cutback mandated



in 1977 and met with MMWD managers to have their allotments increased.

- ° Public services, such as schools and government agencies, undertook conservation measures earlier than most privately owned businesses, thereby reducing their consumption in 1976.
- ° As shown in Table 2, consumption for businesses overall rose slightly in 1976; however, by 1977 their consumption had decreased by 37 percent of what it had been in 1975.
- ° Most businesses experienced little or no change in labor force, aside from labor employed in landscape maintenance.
- ° As was the case for residents, most conservation measures adopted by businesses were implemented in 1977 after stringent rationing went into effect.
- ° Where business revenues are directly related to water use, as in the case of motels and laundries, less of a reduction in water consumption was found (see Table 3).

#### Livestock Ranchers

Livestock ranchers in west Marin County were hard hit by the drought, during which their lands received in 2 years less than 75 percent of the rainfall normally received in just 1 year. Acute feed and water shortages developed on many ranches in the early spring of 1976, following the first dry winter. Some ranchers started hauling in water as early as February of 1976.

Marin County helped ranchers through the drought by setting up emergency feed and water hauling programs. The first emergency hauling program ran from September 1976 to April 1977 and the second from April 1977 to the end of the drought in early January 1978. The response to the Department's questionnaire

Table 2. AVERAGE DAILY CONSUMPTION FOR BUSINESSES IN LITRES (AND GALLONS)

1975	1976	1977
14 482 (3,826)	15 347 (4,054)	9 146 (2,416)

Table 3. AVERAGE DAILY PER CAPITA CONSUMPTION IN LITRES (AND GALLONS) BY BUSINESS TYPE

Business Type	1975	1976	1977
Restaurants	4 754 (1,256)	5 084 (3,728)	2 739 (2,649)
Motels	10 263 (2,711)	11 648 (3,077)	8 902 (2,352)
Laundries	13 994 (3,697)	14 112 (3,728)	10 027 (2,649)
Schools	11 090 (2,930)	7 611 (2,011)	6 446 (1,703)
Government Agencies	5 265 (1,391)	3 266 (863)	1 739 (460)

in February-March 1977 substantiated the ranchers' need for drought assistance and provided the kind of data necessary to obtain federal drought aid from the U. S. Departments of Agriculture and Labor and the Small Business Administration. The information obtained in the survey was also used to design the scope of water deliveries in the County's second emergency water hauling program through 1977.

In all, more than 155 000 cubic metres (41 million gallons) of water were hauled to ranchers. At the peak of the second program in November 1977, 1 325 cubic metres (350,000 gallons) were hauled daily to 53 ranchers and 16 domestic users short of water. Expenditures for water hauling totaled \$484,270, with the County absorbing 54 percent of the hauling costs, the Federal Govern-

ment 37 percent (through the Comprehensive Employment Training Act), and the ranchers 9 percent.

In addition, 120 of the 141 ranchers in the County received a total of \$900,000 in grants to help pay for fodder purchased during the drought. Additional

grants of \$58,000 were made to 34 ranchers to improve farm water supplies. Ranchers' indebtedness attributable to the drought exceeded \$1,000,000. Seventeen of the 68 ranchers responding to the questionnaire were confident they could continue operations without some form of financial assistance.



*The ranches of Marin County were one of the first economic sectors to feel the effects of the drought. The usually lush pastures, a main source of livestock fodder, dried up when the normal winter rains did not come.*



### CHAPTER 3. MEASURES TAKEN TO COMBAT THE DROUGHT

The residents of Marin County struggled through 1976 with a low-key water rationing program and a high hope that the coming winter would bring the needed rain. When the rain didn't come, the Marin Municipal Water District stepped up its rationing program and began exploring ways to obtain additional water, including such imaginative but ultimately infeasible ideas as floating large rubber bags full of water down the coast, shipping water on barges from the State of Washington, and borrowing portable desalting units from the U. S. Navy.

The solution did not lie underground either, because the district had spent \$185,000 drilling wells without discovering any significant amounts of ground water.

However, a pipeline across the Richmond-San Rafael bridge proved to be the most important adjunct to the rationing program, along with trucking in reclaimed and potable water and graywater use.\* The pipeline, the planning and construction of which was negotiated by the Department of Water Resources, provided an average of 50 percent of district-wide consumption during the period it was used and as much as 74 percent during September 1977.

#### Water Rationing

MMWD's water supply is obtained from rainfall on two watersheds of approximately 23 square kilometres (28 square miles) and stored in a series of five lakes. The supply is thus particularly sensitive to rainfall. Although MMWD's water supply system was designed to accommodate normal dry periods, it was not adequate for the 1976-77 drought.

---

\*Potable water is any water that is drinkable, and graywater is any house waste water except toilet water.

Faced with the complex problem of reducing water consumption to levels commensurate with available supply, MMWD explored numerous approaches to the problems of water shortage in 1976 and 1977. To be effective, a rationing program would have to quickly decrease district-wide consumption as well as create only minimal hardships for water consumers. MMWD management (in conjunction with the media) carefully delineated the options for stretching the limited water supplies.



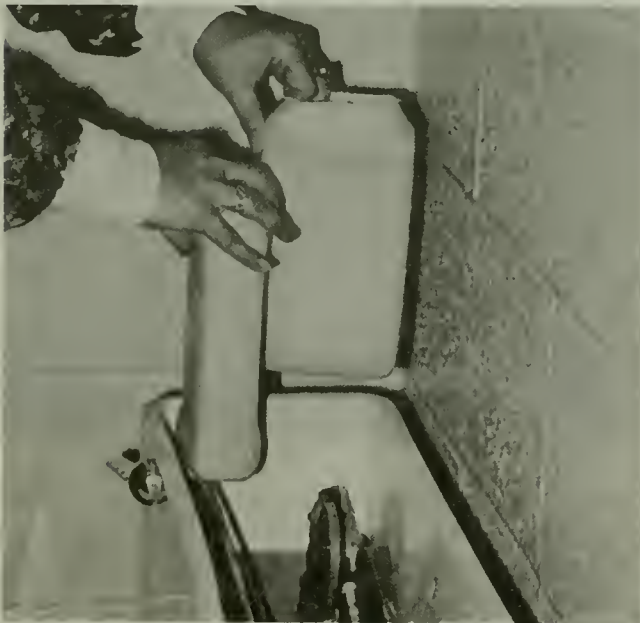
*As the drought continued, cracked earth appeared where water should have been in Nicasio Reservoir, above, and in the four other MMWD storage reservoirs -- Lagunitas, Bon Tempe, Alpine, and Kent. The total capacity of these five reservoirs is 64,480 cubic dekametres (52,440 acre-feet).*

In 1976, MMWD adopted a mandatory rationing program, the principal thrust of which was to reduce peak water use in the summer months by 25 percent. Prohibited were "nonessential" uses such as watering with sprinkler systems, hosing hard surface areas, washing vehicles, and filling swimming pools. Variances were granted for health and safety reasons and sprinkler permits were available to certain institutional and commercial customers with large irrigation requirements.

As the drought intensified and water supply conditions worsened in 1977, elements of the rationing scheme were changed. Stringent rationing effective February 1, 1977, set a per capita water allotment without restrictions on how the water could be used. As Figure 2 shows, the allotment was 185 litres (49 gallons) a day per person, or less, depending on the number of people living in a single residence. This rationing required a 57 percent reduction in normal consumption. Table 4 presents a summary of the principal elements of the rationing programs as they evolved since February 11, 1976, including water rate increases.

Despite the severity of the water shortage situation in 1977, MMWD remained flexible and responsive to its customers. Informational newsletters were sent to customers describing the rationing program and emergency water supply possibilities. Rationing information included water consumption estimates in gallons per minute of common household fixtures and appliances. These figures gave customers an idea of what water-using behaviors or methods could be modified to conserve water. Customers were allowed a 2-month penalty-free learning period after February 1, 1977, to monitor their water use and alter water-using habits. Water-banking was implemented in the summer, allowing residents credit for allotted water not used. Other services to customers included leak repair and meter reading instruction.

Water use in the service area was subject not only to stringent rationing restrictions, penalties, and other incentives curbing water consumption, but simultaneously to an intensive education and retrofit program and campaign to conserve water. Retrofitting is mechanically reducing water usage of an installed fixture without materially affecting its



*Many Marin residents installed retrofit devices in their toilets and showers, and thousands of households received kits with instructions on water-saving practices.*



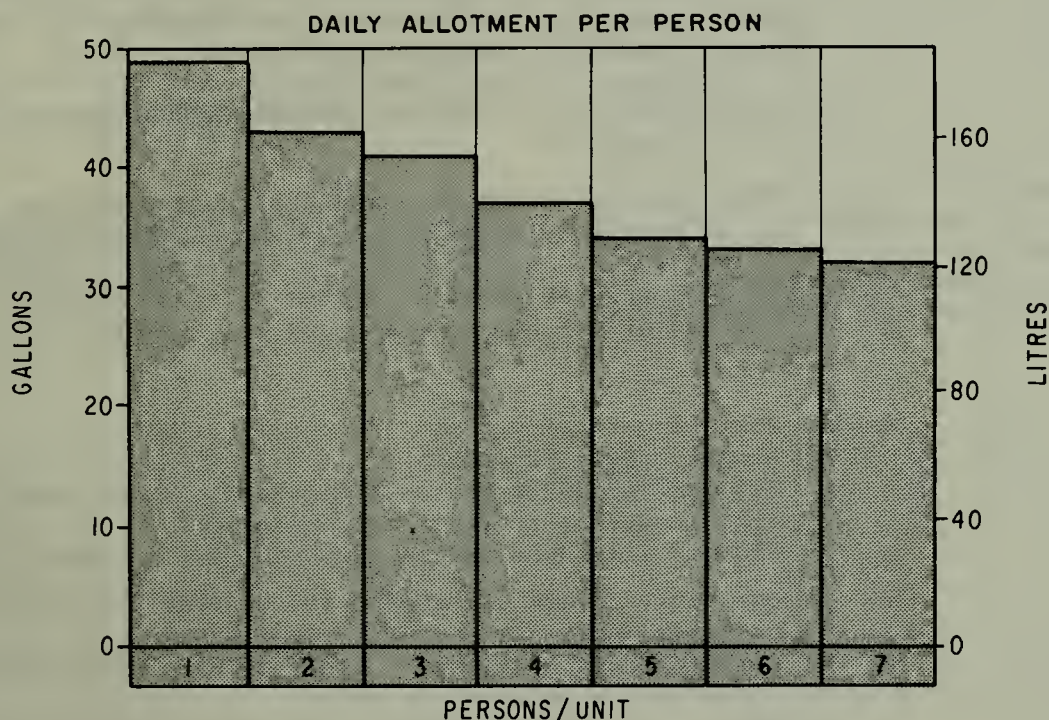
## Figure 2. WATER RATIONING ALLOTMENTS

(Effective February 1, 1977)

### Single-Family Residence or Duplex

The allotment for a single-family residence or duplex is based on the number of persons residing in that unit (for at least 6 months during 1977). The number of persons in the unit is multiplied by the corresponding rate of water use in litres (or gallons) per person per day as shown in the following diagram.

For example, a four-person household would be allotted approximately 140 litres (37 gallons) per person per day, or a total daily household allotment of 560 litres (148 gallons).



### Apartments (3 or more units)

The allotment for three or more residential units (apartment complex) is based on the average number of persons per unit (census taken by apartment owner) multiplied by the number of units.

### Businesses (all other uses)

All other uses (business and commercial): 57 percent reduction from normal use, which is equivalent to a reduction of 48 percent of 1976 water use. This was changed to 35 percent of 1976 in June 1, 1977, when the pipeline across the Richmond-San Rafael Bridge was put in.

Table 4. SUMMARY OF RATIONING ORDINANCES BY MARIN  
MUNICIPAL WATER DISTRICT IN 1976 AND 1977

Effective Date	Rate Change per 2.8 cubic metres (100 cubic feet)		Water-use Restrictions/Penalties
	Previous Rate	New Rate	
<u>1976</u>			
2/11			Prohibition of waste, nonessential uses (gutter flooding)
3/1	\$0.43	\$0.61	Initial drought rate (\$4 meter charge) Prohibition of nonessential uses: 1. Sprinkler systems: hand-held hose only. 2. Washing or hosing of hard-surfaced areas and motor vehicles except with 11-litre (3-gallon) container. Disconnection of service after two warnings and installation of a flow restrictor at the meter.
4/28			Prohibition of filling any swimming pool emptied on or after April 29.
7/28	\$0.61	\$0.61/ 0.84*	*Two-step (peak load) residential rate structure: \$0.61 up to bimonthly usage ceilings established for residential classes. \$0.84 for water usage in excess of these usages. Filling of any new swimming pool prohibited.
<u>1977</u>			
2/1	\$0.61/ 0.84	\$1.22	Rationing rate Penalty rate structure: \$10 per 2.8 cubic metres (100 cu. ft.) used in excess of allotments--up to twice said allotment. \$50 per 2.8 cubic metres (100 cu. ft.) in excess thereof. Bimonthly usage allotments established for each class of water user. Noncompliance to result in service disconnection and installation of flow restrictor. General Manager may grant variances or adjust allotments.
6/1			Bimonthly usage allotment to nonresidential users increased.
7/1			Rules for noncompliance were eased--no restrictors installed.
8/1	\$1.22	\$1.34	Rationing rate (10 percent inflationary increase)
10/1	\$1.34	\$1.87	For consumption over 11.3 cubic metres (400 cubic feet) an additional \$0.53 per 2.8 cubic metres (100 cubic feet) pipeline charge is levied to pay for pipeline conveying water across the Richmond-San Rafael Bridge.

NOTE: In February 1978, penalty rates were removed and an interim rate of \$0.87 per 2.8 cubic metres (100 cubic feet) established.



function. Community and media efforts heightened the awareness of the water shortage and the need to conserve, and communicated various ways of saving water.

News of the rationing program spread far beyond the borders of Marin County. Rationing and conservation measures instituted by MMWD were adopted by other water supply agencies throughout the State as the drought worsened. As mentioned above, MMWD set a water conservation target of 25 percent below normal for 1976 and 57 percent below normal for 1977. The comparison of actual water consumption throughout the district and the consumption levels set as targets for the different rationing programs employed in 1976 and 1977 is displayed in Figure 3. The figure shows actual consumption over the two calendar years and approximate normal consumption for comparison.

In 1976, actual consumption corresponded with planned consumption, representing the 25 percent reduction. However, the

most compelling story represented by Figure 3 is that actual consumption in 1977 was lower even than the 57 percent below normal called for. The actual reduction in consumption achieved in 1977 amounted to a 63 percent reduction from normal.

Figure 4 shows the drastically reduced runoff from the Lagunitas and Nicasio watersheds, the major source of water for MMWD.

During the drought, water storage dropped as consumption and evaporation far exceeded reservoir replenishment. Figure 5 shows how reservoir storage began to fall in 1975 and continued falling through 1976. It also shows a leveling off of storage in 1977. Water storage remained stable beginning in February 1977, when stringent rationing went into effect. This stability reflected the effectiveness of the rationing program in reducing consumption, and the delivery of water via an emergency pipeline across the Richmond-San Rafael Bridge beginning in June 1977.

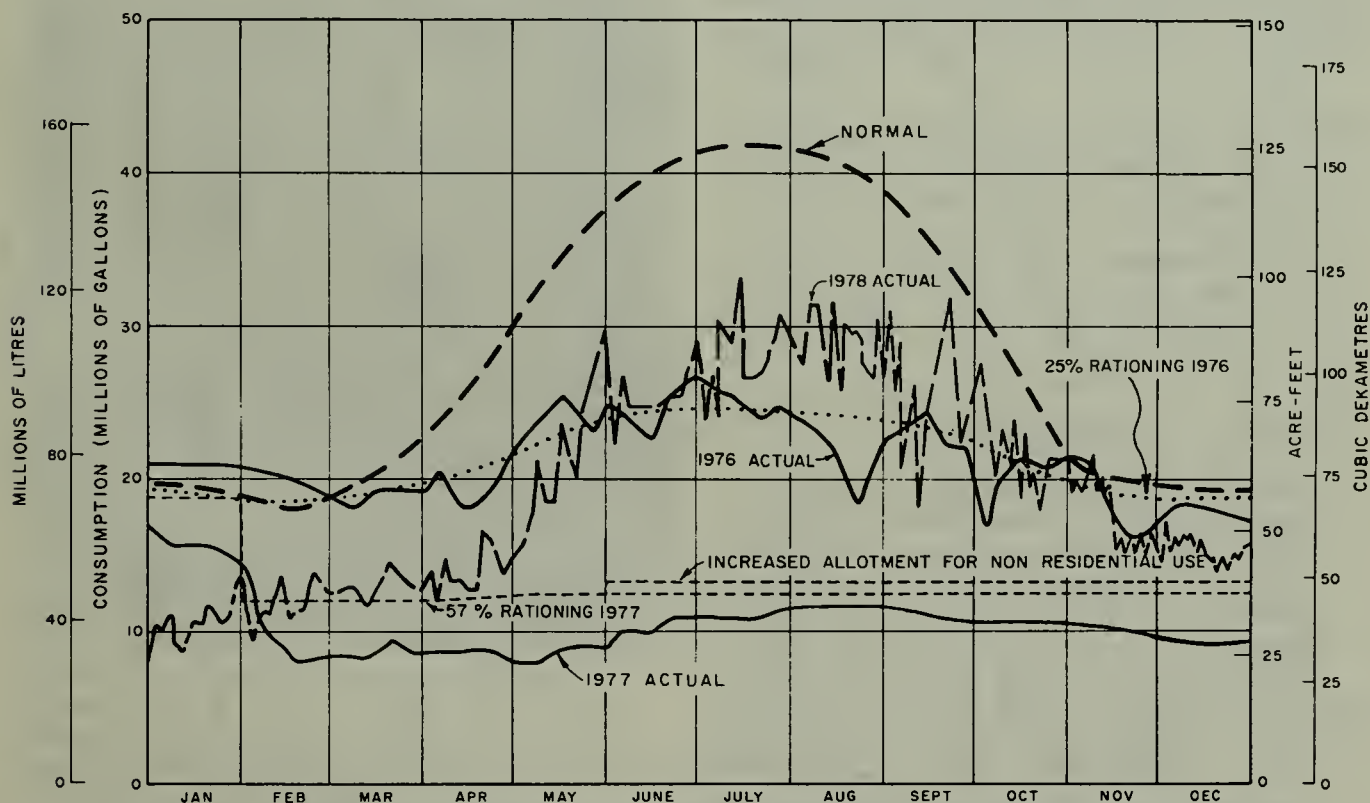


Figure 3. WATER CONSUMPTION—MARIN MUNICIPAL WATER DISTRICT

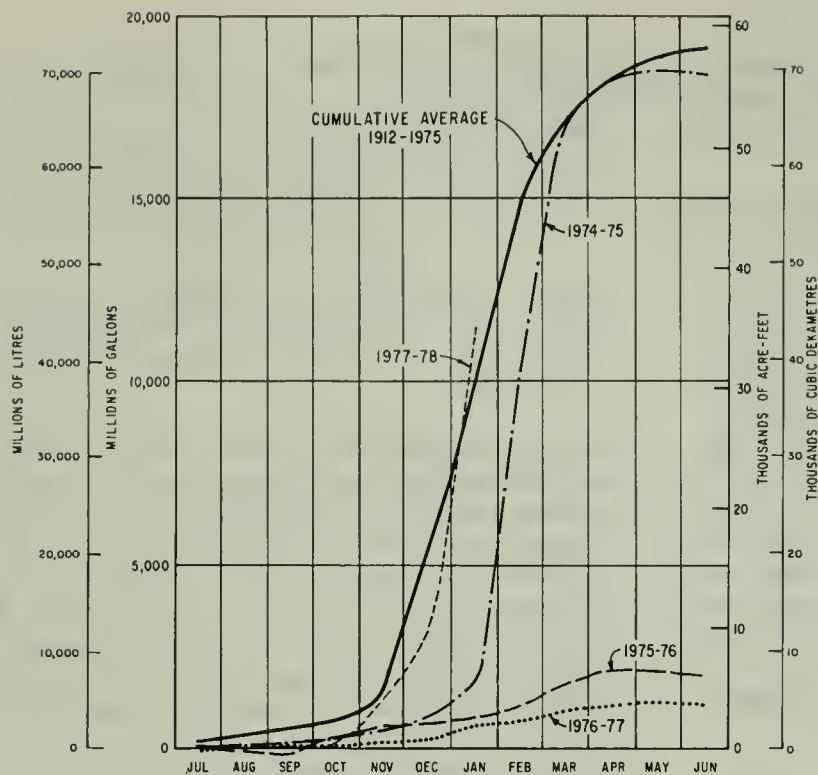


Figure 4. COMBINED RUNOFF -  
LAGUNITAS AND  
NICASIO WATERSHEDS

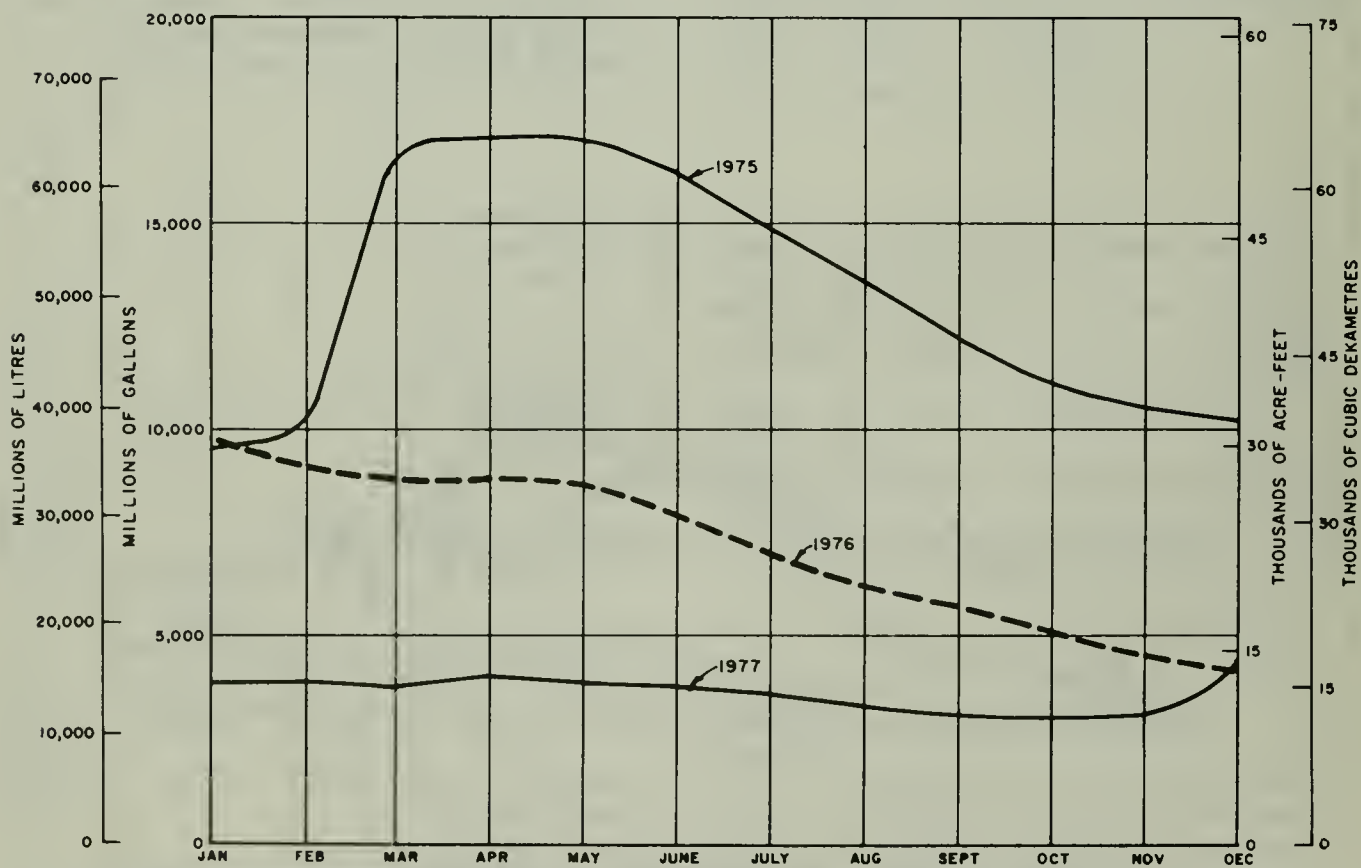


Figure 5. RESERVOIR STORAGE- MARIN MUNICIPAL WATER DISTRICT

### Pipeline to Marin County

In their search for a reliable alternate source of water, MMWD managers met with officials of other water districts as well as officials from the State Department of Water Resources. State officials acted as facilitators in bringing various water districts to an agreement by which water could be transported to Marin County from the State Water Project (SWP) through existing facilities.

As a result, the Metropolitan Water District of Southern California agreed in February 1977 to reduce its demands on the SWP by up to 500 000 cubic dekametres (400,000 acre-feet). The water thus freed for use elsewhere was made available to agricultural users, mainly in the San Joaquin Valley, and to San Francisco Bay Area urban users. MMWD was the principal urban beneficiary of this water.



*This 610-millimetre (24-inch) pipe carried water from the SWP across the Richmond-San Rafael Bridge to Marin County in 1977, easing the drought in the County's urban eastern section.*

A complicated water transfer scheme was worked out. The Department of Water Resources provided water from its South Bay Aqueduct and delivered it into San Francisco's San Antonio Reservoir near Sunol. San Francisco stored and treated the water and delivered it to Hayward for transmission through Hayward's facilities to the East Bay Municipal Utilities District service area. East Bay MUD constructed a connecting facility and delivered an equivalent amount of water to a pumping plant constructed by MMWD in Richmond near the easterly terminal of the Richmond-San Rafael Bridge. The Department of Transportation agreed to the use of a lane on the bridge for the placement of a pipeline, installed by MMWD, conveying water to Marin's existing facilities near San Rafael.

The first SWP water began flowing into San Antonio Reservoir on April 4, 1977. The first water through the pipe arrived in San Rafael on June 7, 1977. With the pipeline, MMWD water users were able to get through the remainder of the drought, conserving more than the 57 percent mandatory rationing program demanded of them.

Although MMWD contracted for 13 300 cubic dekametres (10,800 acre-feet), only 5 667 cubic dekametres (4,595 acre-feet) was actually used before drought-breaking rains fell in December 1977 and January 1978. The total cost of the water taken by MMWD was \$538,596.

### Reclaimed Water

Waste water reclamation became a part of MMWD's total water supply system in March 1976. At that time, the San Francisco Regional Water Quality Control Board and the State Department of Health Services issued a permit allowing reclaimed water to be trucked from three local sewage treatment plants for nonresidential landscaping and construction use. As rationing restrictions increased in 1977, a second permit





*Signs announced the use of reclaimed water for landscaping at the Marin County Civic Center in San Rafael. The center was designed by Frank Lloyd Wright.*

was issued allowing reclaimed water of a higher quality to be used for residential irrigation as long as rationing restrictions were in effect.

Under the first permit, nine hundred drivers were licensed to haul the reclaimed water, which they obtained free of charge and sold to the public and private sectors for a penny or two a litre (4 to 9 cents a gallon). Precautions were taken to insure the water was used for irrigation only.

Forty-five million litres (12 million gallons) of reclaimed water were used in the first year of the drought and 190 million litres (50 million gallons) in the second year, mostly for nonresidential landscapes at schools, parks, and commercial establishments. Using reclaimed water for maintaining lawns and gardens became more widely accepted by Marin County residents due to the drought experience. Ninety-four percent of the households responding to DWR's survey indicated they would be willing to use

reclaimed water for irrigation if it were available.

The reclaimed water used for residential irrigation during 1977 under the second permit was obtained from the Las Gallinas Project, a water reclamation facility being developed by MMWD. This facility gets secondary-treated municipal waste water from the Las Gallinas Valley Sanitary District. This reclaimed water was sold to truckers for \$1 per 3 785 litres (1,000 gallons). The Las Gallinas project is going through various design and planning stages, each of which must be approved according to the State Water Resources Control Board's clean water grant process. During the drought, temporary above-ground lines were installed to meet the needs of several large users, such as McGuinness Park and the Las Gallinas Golf Course.

The Las Gallinas Project is scheduled to be completed by the end of the summer of 1979. Its peak capacity will be about 3 800 000 litres (one million gallons) per day or 1 357 cubic dekametres (1,100 acre-feet) per year. However, the facility will probably average 500 to 600 cubic dekametres (400 to 500 acre-feet) per year depending on demands. The system is planned to provide water lines paralleling fresh water lines in some new developments. Treated water from the Las Gallinas Project may be used for irrigating parks and landscaping for businesses, highways, and residential areas consisting of multiple dwellings where irrigation is not directly controlled by residents. Reclaimed water will be sold at 95 percent of the price of fresh water to provide an incentive to the consumer.

The future success of Las Gallinas and similar projects is still uncertain. The Department of Health Services revised the regulations on the use of reclaimed waste water on October 22, 1978. The quality standards were raised, limiting the use of water from projects such as Las Gallinas. The project is currently operating under a discharge

permit that was issued before the new regulations went into effect. Project managers are undecided on whether to continue supplying water to a limited number of customers or to upgrade the effluent from the project to meet the new regulations and increase the number of customers that can use the treated water.

#### Potable Water Hauling

While urban residents and commercial developments were trucking reclaimed water for irrigation, residents and livestock farmers of rural areas in West and North Marin were hauling potable water to take the place of wells, creeks, and ponds that had dried up.

The potable water was supplied by the North Marin County Water District and the City of Petaluma Water Department. Private trucking companies and some ranchers obtained the water from various hydrants and delivered it to customers. The costs to the consumers for hauling the water were so great that the Marin County Board of Supervisors authorized a county-funded hauling program. Residents and ranchers who took water on a regularly scheduled basis paid 18 cents per 1.6 kilometre (1 mile) for the hauling, which was supervised by the County Department of Public Works. The water was paid for by the customers. Many small users did not take advantage of this program, since not all had storage tanks large enough to accommodate bulk loads.

#### Graywater

Graywater was another alternate source of water that many Marin County residents turned to during the drought.

Table 5 shows the percentage of single family residents responding to DWR's survey who used graywater in some way.

As Table 5 indicates, the percentage of people using graywater for different purposes greatly increased in 1977 from 1976.

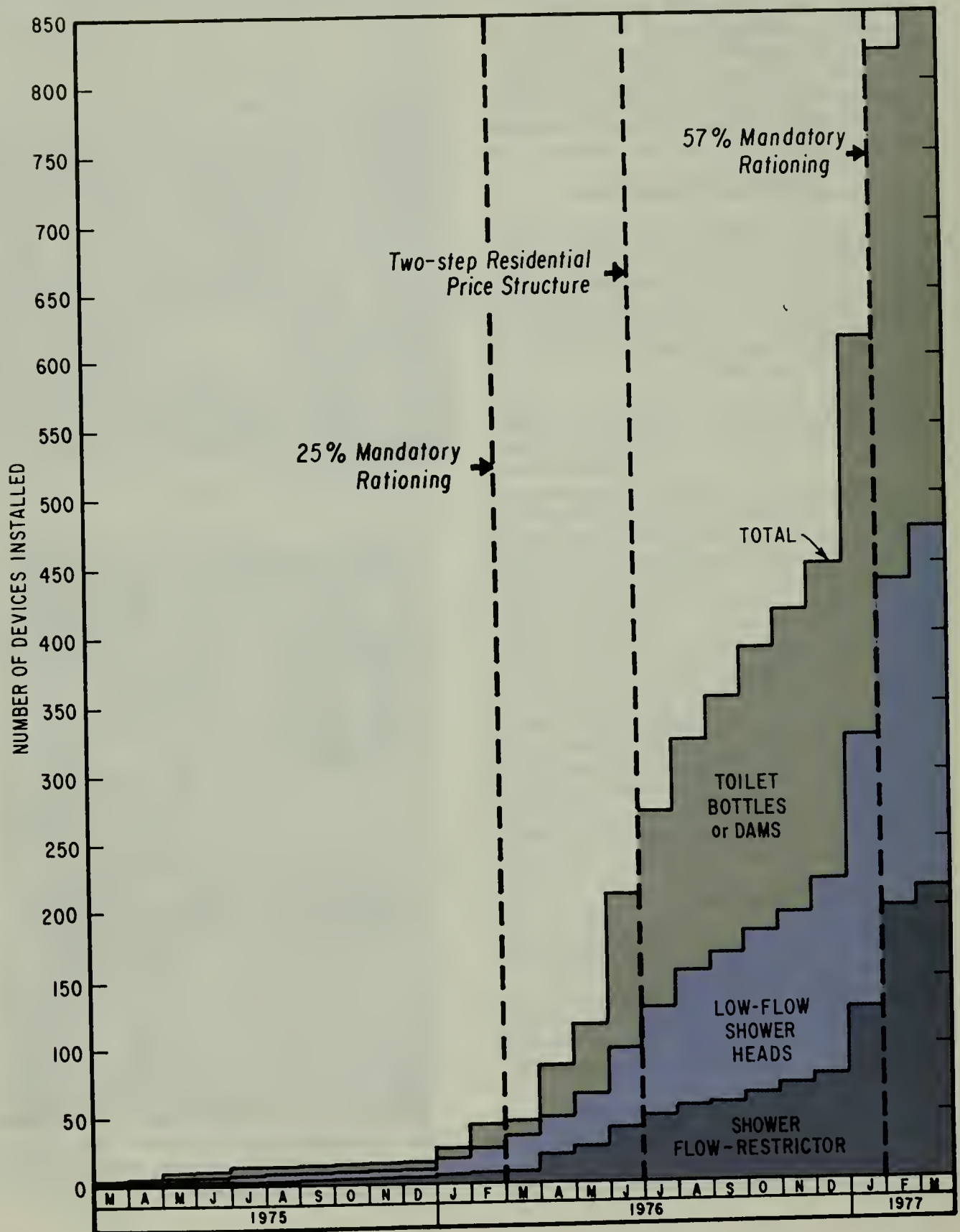
Table 5. PERCENTAGE OF SINGLE FAMILY RESIDENTS USING GRAYWATER

	<u>1976</u>	<u>1977</u>
Total households implementing one or more of uses below	35.0	80.8
Unspecified reuse	18.7	34.6
Reused:		
- bathwater	3.7	13.6
- laundry water	3.9	15.0
- dishwashing water	2.1	7.5
- vegetable wash water	-	0.3
- cold water from hot water tap	1.3	4.2
Used graywater:		
- to flush toilet	5.0	27.1
- on plants and garden	12.2	29.7
- in garbage disposal	0.1	0.7
- to wash car	0.1	0.3
- for general cleaning	0.4	2.1



*This graywater system stores both rainwater and washing machine rinse water for landscape irrigation.*

Figure 6. TIME COMPARISON OF CONSERVATION DEVICES AND RATIONING RESTRICTIONS





## CHAPTER 4. EFFECTS OF WATER SHORTAGE ON RESIDENTIAL WATER USERS

Since more than half of the water supplied by MMWD is consumed by residential customers, the main focus of MMWD's rationing program was on the residential water user. The Department's survey documented how the residents of Marin County cut back consumption, how they felt about MMWD's rationing program, and what factors were important determinants of water consumption.

### Residential Indoor Water Use

Attempts to conserve water revealed that appliances and fixtures considered to be "essential" to daily living actually were water guzzlers. Toilets and showers/baths become water wasters if left ungoverned during drought situations such as that suffered by Marin County residents in 1976-77.

In order to adjust indoor water consumption to rationing allotments, community members dramatically changed their patterns of indoor water use. Virtually all respondents (from all dwelling types) installed water-saving plumbing devices. Figure 6 shows a cumulative representation of the most popular devices installed and the dates on which MMWD rationing schedules were instituted for single family dwellings. Installations appear sparse prior to initial prohibitive rationing measures of March 1, 1976. Installations increased dramatically with the rationing measures of March 1, 1976, the rate increases of July 28, 1976, and the 57 percent mandatory allotment rationing of February 1, 1977. (For a more complete statement on the rationing schedule, see Table 4 in Chapter 3.)

Besides installing devices, community members instituted many and varied measures and restrictions to reduce indoor water use, notably: less frequent laundry washing (including larger loads), handwashing of dishes, less frequent

toilet flushing and bathing, and shorter showers. The bathroom appeared to be the major indoor area where measures and restrictions were adopted. Graywater use was also adopted by many respondents from each dwelling type. Although graywater was used in 1976, dramatic increases were noted in 1977.

Overall, it appears that respondents were actively adopting water conservation practices. However, the fact that most of these practices occurred following the institution of rationing measures suggests that active indoor as well as outdoor conservation practices may need rather strong incentives for implementation when drought and water rationing are not present. Yet, such active participation in water-saving activities allowed Marin County residents to reevaluate their water consumption habits. By the end of the summer of 1978, water use by MMWD customers was still 35 percent below predrought use. Despite high rainfall, Marin County residents continued to observe at least some of the water conservation habits they had developed.

### Residential Outdoor Water Use

A large part of the water used by residents is used outdoors, mostly to maintain landscaping and swimming pools. As the water reserves in Marin County diminished and water use restrictions tightened, residents were faced with the double challenge of conserving water while trying to avoid sizeable landscape losses.

Outdoor watering practices were modified throughout 1976 and were continually reappraised and modified up to March 1977 when the Department's survey was taken. The initial watering practices used were generally reductions in frequency and amount of watering. By

March 1977, attitudes toward outdoor watering and prevailing watering practices had dramatically changed from the early days of the drought. MMWD customers were learning how, through education and trial and error, to cope with the dry weather.

Those surveyed were asked to identify how they would continue (if at all) to water landscaping in 1977 under March 1977 restrictions and continuing drought. All three residential sample groups had two major intentions for 1977 outdoor watering. The major intention of all three groups was to use various sources of water other than MMWD, including graywater and reclaimed water. The second major intention of single dwelling and duplex respondents was to water selected parts of landscaping, while the second major intention of apartment owners and managers was to apply various watering devices such as sprinkling cans and drip irrigation systems.

It is clear that as drought conditions grew increasingly serious, community members began to recognize the need to make greater expenditures of time (for recycling water) and money (for purchasing trucked water or drip irrigation systems) in order to avoid inevitable landscape loss. Watering practices used earlier in the drought could be either supplemented by the more expensive practices or completely replaced by them.

Regardless of the type of practices actually implemented after the Department's survey, it is obvious that the respondents expected to spend more to save their landscaping than they originally thought would be necessary. The following section presents an appraisal of the losses and costs of drought incurred up to the time of the survey.

#### Losses and Costs as a Result of Water Shortage

Losses and costs are usually observed in terms of replacement price in the marketplace. The loss of a juniper bush that

costs \$25 to replace is \$25. However, there are other loss values not identified in market transactions. For example, a number of the survey respondents (especially residential householders) said they lost "old", "invaluable", or "cherished" plants. Such losses cannot possibly be stated in dollar values. Additionally, a dollar value was difficult to assess at survey time because only 10 percent or fewer of the MMWD customers polled had yet replaced or changed their landscaping.

As a result, losses in this section are stated not in dollar values but as physical losses in landscaping: trees, shrubs, lawns, and ground cover. On the other hand, costs are presented in dollar values and are generally considered to fall into such areas as purchasing of water from sources other than MMWD, water-saving plumbing changes and leak detection and repair (both cost-reducing in the long run), labor costs for watering, and purchasing containers to catch water.

#### Losses

Comparing losses among the various types of landscaping is difficult because data on the use of each type of plant are not available. It is clear, however, that lawn and shrub losses were extensive and virtually universal throughout the District. The heavy loss of shrubs and lawn (and ground covers in general) is not surprising because they are generally not drought tolerant and are more easily replaced compared to trees. (They are thus sacrificed first.) The expectation of all three groups of respondents at the time of the survey was that they would continue to lose trees and shrubs.

One-third of the single dwelling and apartment house respondents and one-quarter of the duplex respondents planned to replace or change landscaping as a result of the water shortage. The most prominent plans of each group involved modifying their landscaping to include more drought-tolerant plants. Very few



members in any of the groups planned to return their landscaping to its predrought status when the drought was over. This suggests that the majority of members of each group recognized the seriousness of the 1976-77 water shortage and further recognized a more long-term need to conserve water and prepare for future water shortages.

### Costs

For the overall sample, the most widely incurred short-run cost appears to involve water-saving plumbing changes (and installation of devices) and leak detection and repair. The cost incurred by a majority of single dwelling respondents was for containers to catch rainwater. A large group of apartment respondents also reported increased labor costs for watering as a result of the water shortage. This is not surprising considering the MMWD partial ban on sprinkling systems and limited issuance of sprinkling permits.

Apartment house respondents incurred the greatest average accumulated cost of all three groups. Their average of \$970 spent far exceeds the \$170 average incurred by single dwelling respondents and the \$75 average incurred by duplex respondents (these exclude landscape loss).

### Community Comments on the Drought

The drought survey concluded by asking MMWD customers to comment on the drought. This section reports a selection of the most frequent comments on MMWD policy and the water shortage in general.

The major comment reported by community members concerned future actions to increase water supplies. Wells and water reclamation were enthusiastically suggested by many as possible sources of water. As noted earlier, not only had reclaimed water become widely used in early 1977 out of necessity, but had become widely accepted at that time. (Early in the drought, both reclaimed

water and graywater were generally mistrusted and thought to be unsanitary and possibly detrimental to health if used widely.)

Interestingly, a number of citizens suggested restrictions in construction. "No new building" (types unspecified) and "no new water hook-ups" were the major comments. "No new swimming pools" was also mentioned, but not as frequently. Despite this sentiment, a large number of citizens felt that MMWD should not be involved in growth control. Individuals further desired MMWD to continue to seek new sources of water until zero population growth was attained.

MMWD customers generally supported the "water bank" concept. They felt that a "water account" comprised of unused portions of monthly water allotments saved (per customer) was a good idea. Many residents also felt that those who are "under-using" ought to pay a lower price for water or at least receive a refund for unused water. (These same individuals generally supported a higher price or penalty for over-users.)

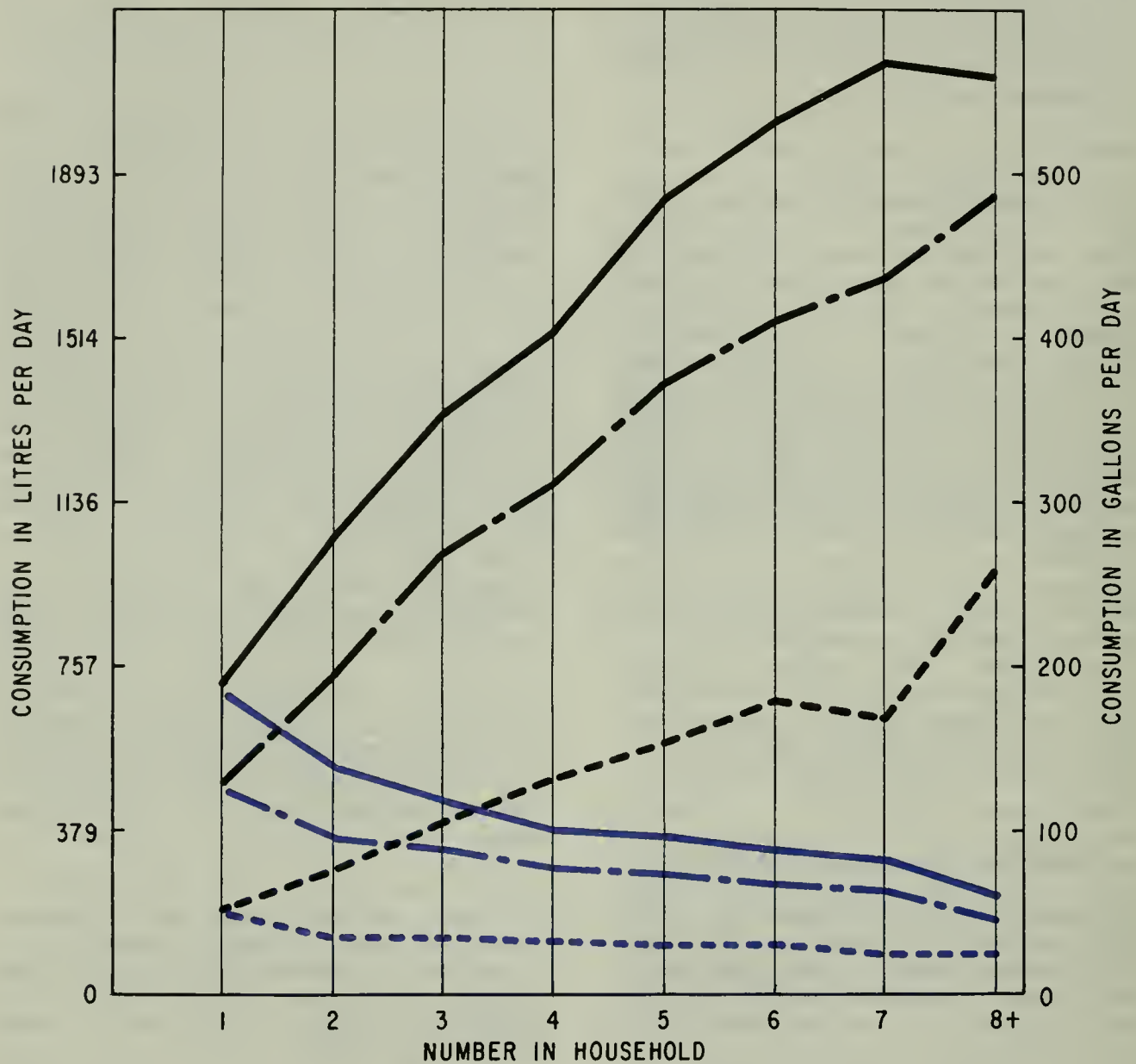
A number of respondents felt that MMWD was doing a good job or doing everything that was possible. However, some members of this group believed that statewide rationing should have been mandatory.

As positive as some were about MMWD's policies, an equal number were dissatisfied and felt the water rationing allotment was inconvenient and time consuming. A few were concerned over questions of health and sanitation when water is rationed.

Very few individuals felt that special allowances or exceptions should be allowed to groups (i.e., single and multiple family residences, business types, etc.) other than their own.

Sentiments on controversial drought policy issues appear to be generally split into equal pro and con factions.

Figure 7. AVERAGE DAILY WATER CONSUMPTION  
PER HOUSEHOLD AND PER CAPITA - 1975-1976-1977



—●— HOUSEHOLD 1975	— PER CAPITA 1975
- - - HOUSEHOLD 1976	- - - PER CAPITA 1976
- - - HOUSEHOLD 1977	- - - PER CAPITA 1977



Thus, developing a drought policy is at best a "tightrope walking" situation. It appears that the most effective drought policy is that which aims predominantly at reducing water use without being overly concerned with who will be pleased or displeased with the policy.

#### Factors Affecting Residential Water Consumption

In conducting this study, the Department sought to determine the most important factors governing water consumption in MMWD. Using the survey data, the Department analyzed water consumption according to housing type by inspecting MMWD's meter records for 1975, 1976, and 1977. The year 1975 was considered to be a normal water use period, 1976 a voluntary rationing period, and 1977 a mandatory rationing period.

Climate is a major factor in residential water consumption because a large part of the water is consumed outdoors, for landscaping and swimming pools. The hotter and drier the weather, the more water is required. Approximately one-fourth of the variation in per capita summer consumption during a normal year in MMWD can be attributed to average monthly summer high temperatures.

The climate within MMWD varies according to geographical area. Service areas in the southernmost part have generally lower temperatures in the summer, due in large part to the fog that blankets areas close to San Francisco Bay and the coast. Summer temperatures are higher in the northern and western reaches of the district. Average residential water consumption by service area was compared for the three years, 1975, 1976, and 1977. In 1975, the normal water period, average consumption varied widely between geographical locations. In 1976, the voluntary rationing period, all areas were using less water but there was still some variation in consumption, depending on the geographical area. In 1977, the mandatory rationing period, all areas were using water at a low, and

almost identical, rate. This indicates that climate is a major factor in water consumption under normal conditions but becomes less important as water rationing becomes more strict and disappears altogether under such conditions as existed in 1977 in MMWD, especially as the outdoor/indoor ratio declines.

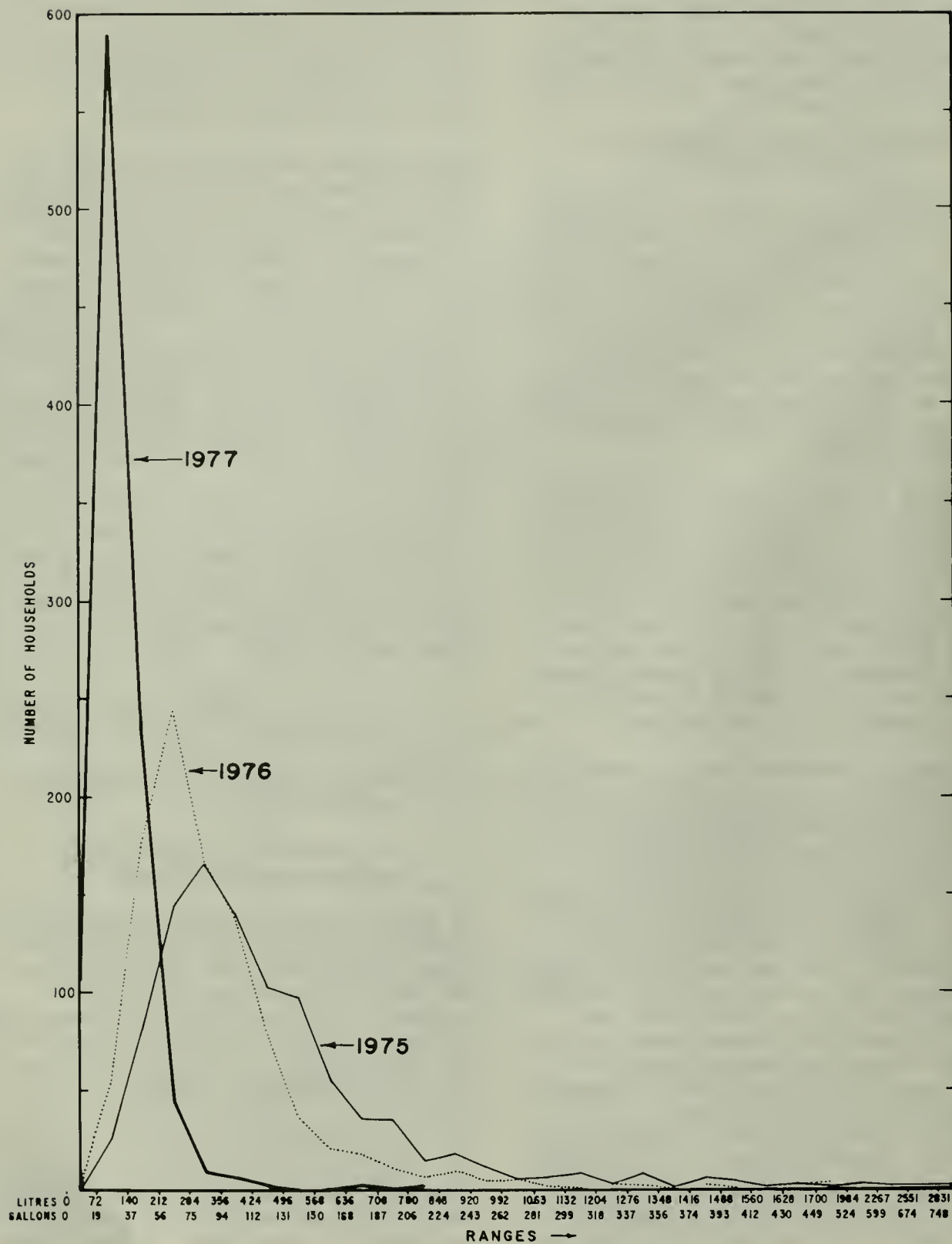
While climate normally has a major effect on water use, a number of other factors also apply. One is housing type and numbers of people per household. For example, a single family residence will use more water per person than a unit in a townhouse. This is primarily due to outdoor water use. The per capita share of landscape watering for apartments is far less when divided among many residents than the per capita share for a single family residence divided only among the immediate family members.

Another important factor affecting consumption is individual household characteristics, such as family size, income and its related factors of size of lot requiring water, number of water-using appliances, and swimming pools. As income increases:

1. The average number of water-using appliances per household increases.
2. The average lot size requiring water increases.
3. The percentage of homes with swimming pools increases.

Of special interest was the fact that as family size increased, overall family water consumption also increased, but per capita consumption actually decreased. This phenomenon is shown graphically in Figure 7. For 1975 and 1976, the more people in a family, the less water each individual used. This is due in part to outdoor watering, which is relatively independent of family size, and somewhat due to indoor activities such as dishwashing and clothes washing, which don't necessarily use water proportionate to the number of family mem-

Figure 8. DAILY PER CAPITA CONSUMPTION



bers. However, note that per capita consumption during 1977 remained relatively stable rather than decreasing. This leveling out is due mostly to the elimination of outdoor watering in 1977.

The variability in water consumption for Marin County residents decreased as rationing measures began taking effect. Figure 8 shows the distribution of per capita consumption for single households over the three consumption periods.

The graph helps show visually the change in per capita consumption from

normal to strict rationing periods. As rationing became more stringent, extremely high residential water users decreased in number (to almost zero when strict rationing was implemented). Water users of all income categories and all household types reduced consumption to an average per capita use of about 125 litres (33 gallons) per day.

In summary, a number of factors affect residential water consumption, but these can apparently be overcome or eliminated when stringent water rationing is enforced.



*San Quentin Prison saved water by watering its ice plant landscaping with salt water from San Francisco Bay, a technique discovered and applied by the Department of Corrections. San Quentin, population 2,000, is one of MMWD's largest single water accounts. Water-saving programs, including retrofitting showers and toilets with water-saving devices, led to a 45 percent decrease in water consumption at the prison.*





## CHAPTER 5. EFFECTS OF WATER SHORTAGE ON BUSINESSES

Only 7 percent of MMWD's customers are businesses, but they account for 28 percent of the District's metered water consumption. Although most businesses installed water-saving devices and made modifications in landscape watering in 1976, their overall consumption rose 6 percent over what it had been in 1975. The majority of the businesses either had not realized the severity of the drought or had not yet employed measures that were stringent enough to decrease their consumption.

The 57 percent mandatory cutback imposed on all water users in February 1977 posed real problems for certain types of businesses, particularly those whose services depended on water. MMWD managers realized that water use restrictions on businesses would have to be flexible, and as a result met with numerous individual business groups to discuss water use and the various ways it could be reduced.

After rationing went into effect, a 2-month learning period provided businesses time to experiment with water-saving techniques to see which would be possible. For some highly water-dependent businesses, such as laundromats, the mandatory allotment was increased. Of the businesses sampled, water meter records show that, overall, they were able to decrease water consumption in 1977 by 37 percent of their 1975 consumption. Although only a very few businesses attempted to have their allotments adjusted, 37 percent felt they should be exempt from the 57 percent cutback and that a 25 percent reduction was more reasonable. One-quarter of those surveyed felt they could not meet the 57 percent cutback and remain in business.

The spectrum of business and community services surveyed was so broad that overall conclusions were not very meaningful. Therefore, in this report the Department has focused on a few specific

businesses and public agencies particularly affected by the drought to provide some specific insights. The following business "types" were selected because their water conservation measures affect the general public:

- government agencies and community services
- schools
- restaurants
- laundries
- motels

The following analyses provide a cursory look at the effects of the drought on these specific entities, and allow a comparison to be made between public agencies and private businesses, where both are providing services to the public. Overall, the data show that both government agencies and schools were able to reduce consumption in 1976 and continued to cut back water use in 1977. In contrast, restaurants, laundries, and motels -- highly water-dependent businesses -- actually increased their water consumption in 1976. All businesses managed to bring consumption down in 1977, but not by the targeted 57 percent. Finally, it is apparent that where income is directly related to water use, particularly where management does not have direct control over water use, as in the case of inside use in motels, less of a reduction in consumption is found.

### Government Agencies and Community Services

Government agencies appeared to have no severe problems meeting the 57 percent cutback in consumption. They reduced consumption by 38 percent from 1975 to 1976 and as much as 67 percent in 1977.

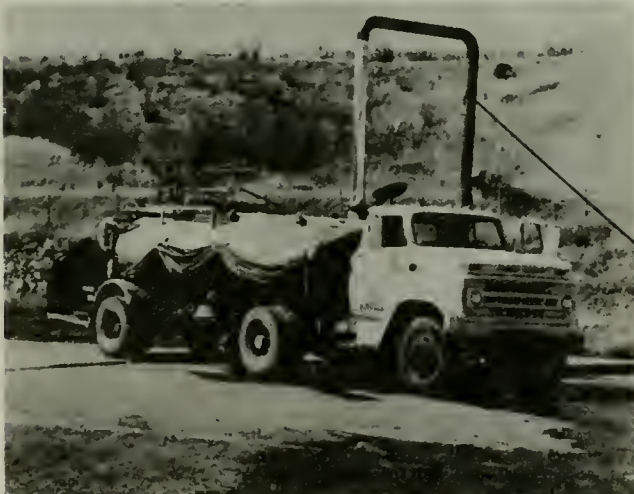
Most government agencies and community services had landscaping that required water, but maintained this landscaping by changing watering practices and using alternate sources of water. Half reported losing some landscape, typically groundcover and trees.

By March 1977, almost all agencies had made changes in indoor water use by repairing leaks, altering plumbing, installing water-saving devices, and educating employees. Although no changes in business revenue and labor force were reported, some costs for water-saving plumbing and leak detection and repair were incurred.

### Schools

Although the schools surveyed failed to meet the 57 percent cutback, the majority did not feel rationing was too stringent. Consumption was reduced by 31 percent in 1976 and 42 percent in 1977.

All schools made changes in landscape watering, particularly by reducing frequency of watering and using sources other than MMWD. Almost all schools maintained landscaping to some extent in 1976; however, two-thirds reported losing some landscaping, most often lawns and groundcover. Indoor water savings were made by installing shower and toilet devices, repairing leaks, and educating employees and students.



*The major drought-related cost for schools was hauling reclaimed water for fields and landscaping.*

In general, the water shortage had no effect on schools with respect to business revenues; however, the standard of service or programs provided to the community were affected in some cases. Even though over half the schools reported having to postpone pending maintenance work, there were no changes in the labor force due to the water shortage.

The major costs reported by schools were for trucking in reclaimed water for irrigation.

### Restaurants

Restaurant water consumption in 1976 was 7 percent over 1975. Most of the restaurants surveyed felt the 57 percent cutback in consumption was a bit severe, but they were willing to make compromises in their consumption. Restaurants decreased their consumption in 1977 by 42 percent over 1975.

The majority of restaurants had virtually no landscaping to speak of and thus had little outdoor water use to contend with. They did make changes in indoor water use such as:

- repairing leaks
- retrofitting spray emitters on dishwashers
- altering plumbing
- educating employees
- serving water to the public only on request
- installing toilet devices

Toilet devices were the most popular water-saving measure implemented.

Employees and employee workload were not significantly affected nor was there any significant loss in business revenue due to the water shortage. A few costs were involved in implementing some water-saving measures, such as purchasing disposable cups, plates, and eating utensils.

WE'RE CONSERVING . . .  
AND HELPING CALIFORNIA  
SAVE WATER AND ENERGY



IF YOU'D LIKE A GLASS OF WATER  
PLEASE LET US KNOW . . .  
WE'LL BE HAPPY TO SERVE YOU!

→→ SOME TIMELY QUESTIONS ABOUT WATER ←←

1. *How many gallons a day does the average person use?*
2. *When does one equal three?*
3. *How much is one times many?*

*(answers inside)*

1. *An average person uses about 150 gallons of water each day.*
2. *Each eight-ounce glass of water served takes another sixteen ounces for washing -- a total of three glassfuls for each glass served.*  
*Besides, it takes energy to make the ice for the water, and to heat the water for washing.*

3. *One times many is a lot! Each day about 10 million restaurant meals are served in California. By not automatically serving a glass of water for each meal, more than a million gallons of water could be saved every day.*

*Savings in energy to transport and treat that water, heat it for washing, freeze it for ice, and to treat the wastes, is also a huge amount.*

*Many restaurants saved water by serving it only on request. "Tent cards" were often placed on restaurant tables to help pass the save water message. The Department made the above card available to restaurants statewide.*



### Laundries

Due to their dependency on water, laundries used slightly more water in 1976 than in 1975. They did manage to decrease consumption in 1977 by 28 percent of what it had been in 1975. However, of those surveyed, all felt the 57 percent cutback was too severe and most were trying to have their allotments changed. In order to reduce consumption, laundries repaired leaks, installed devices, limited wash cycles, and recycled rinse water. Recycling was found to be the most practical and effective practice adopted.

Laundries incurred costs of installing new coin slides due to increased prices and signs to educate the public. Although the majority had not incurred any losses in business revenue, all expected to lose revenue if the drought continued.

### Motels

Of the businesses surveyed, motels were the hardest hit by the mandatory ration-

ing. Their consumption rose 14 percent in 1976 above what it was in 1975. In 1977, they managed to reduce consumption to only 13 percent below 1975 figures.

Motels changed their outside watering methods in addition to making changes in indoor water use. Toilet and shower devices, as well as signs to the public, were found to be the most effective measures adopted. In some cases, linen service was affected.

In general, motels did not lose business revenue, but did incur costs for implementing water conservation measures and did expect future costs or losses.

The majority of motel operators felt they should be exempt from the 57 percent cutback and were attempting to have their allotments changed. Several motel owners/managers complained to MMWD managers that residents of Marin would join out-of-town friends or relatives staying at local motels and use the shower facilities. Thus water consumption was at least partially out of their hands.



## CHAPTER 6. EFFECTS OF WATER SHORTAGE ON LIVESTOCK RANCHERS

Livestock ranchers in Marin County, the first county in California to develop a major dairy industry, were severely affected by the prolonged drought of 1976 and 1977. Many suffered serious financial hardships, a few were forced out of business, and the average level of farm indebtedness rose appreciably. Nurserymen were similarly affected, many having to seek low-interest federal drought relief loans to remain in operation.

In Marin County, especially in west Marin, many ranchers rely on springs, small dams, creeks, and wells for water supply for livestock and washwater for dairy barns and utensils. The remote and dispersed location of the farms means the distribution costs of a more reliable water supply are beyond the ability of most ranchers to pay.

Early rains in the fall followed by warm weather and intermittent rains of 2 or more inches at monthly intervals, continuing until late in the spring, greatly increase pasture productivity.

"Good grass" years reduce the ranchers' need to purchase hay and supplements from off-farm sources to maintain livestock. The heavy reliance on farm-grown pasture for livestock means the distribution of adequate rainfall throughout the growing season is vital to farm productivity and the ranchers' economic well being.

This need for evenly distributed rainfall resulted in the ranches of Marin being one of the first economic sectors in the county to feel the drought's effects, which built up over many months from the dry fall of 1975 and the subsequent winter and spring of 1976. Water supplies from ponds, dams, and wells dried up completely on many of the farms. Pastures usually verdant and lush, a main source of livestock fodder, became dessicated bare fields prone to water and wind erosion; hay reserves were depleted; feed had to be trucked in from as far as Idaho while water had to be hauled daily to farms, some receiving water daily for as long as 18 months to keep livestock productive and in some instances barely alive.



*Many ranchers, especially those in west Marin, were forced to haul in water daily for as long as 18 months to keep their livestock alive and well. County and federal funds helped defray costs, which totalled nearly half a million dollars by the end of the drought.*

Throughout the drought, monthly rainfall commencing with the winter of 1975-76 and continuing through the fall and winter of 1976-77 was far below the long-term monthly average for almost all months. From November 1975 to October 1977, for example, 749.3 millimetres (29.50 inches) of rain were recorded at San Rafael, 235 millimetres (9.25 inches) less than that received in one year of normal rainfall. Even in years when rain is not greatly less than normal, many dairies are acutely short of water.

It could be expected, therefore, that the failure of the seasonal fall and winter rains in 1975-76 (one-third normal) would result in acute water shortages on some farms as early as late winter of 1976. A few ranchers began hauling water in February 1976. Increasing numbers of them had to resort to hauling water to their herds as water supplies became depleted during the summer of 1976. By September 1976, west Marin ranchers were paying an average of \$2,000 per month to have water trucked in.

It was evident that costs of trucking in water coupled with extremely high costs of trucking in hay would quickly force many ranchers out of business. In September 1976, the Marin County Board of Supervisors voted to defray half the water hauling charges up to \$40,000 until January 1, 1977. The county would also coordinate water tanker operations and water deliveries to the west Marin ranches. This commitment was the first phase of an effort that ballooned into a full-scale program of water hauling, subsidized by the County and the Federal Government, that did not terminate until January 1978. In mid-February 1977, during the first phase of the water hauling program, the Department mailed out a questionnaire to 141 Marin County livestock operators -- dairy, beef, and sheep ranchers -- asking them for information on the costs and losses they had suffered to date, the adequacy of their water supplies, and the measures they had taken to develop or supplement those supplies.

The responses to this survey confirmed that the water supply situation was severe and getting worse. Among other things, the survey showed as of mid-March 1977 that:

- ° 53 000 cubic metres (14 million gallons) had been hauled to 19 of the 68 ranchers responding, while another 39 ranchers stated they would have to bring in water either by tanker truck or by pipe from an off-farm source.
- ° Water hauling costs exceeded \$65,000, while about 10 000 tonnes (11,000 tons) of additional feed had to be purchased at \$953,000 to sustain livestock.
- ° 20 ranchers had to borrow more than a total of \$1 million in 1976 and the need for loans in 1977 was estimated at an additional \$1 million to defray feed and water costs.
- ° Only 18 out of the 68 ranchers responding were confident they could stay in business without financial assistance in the form of either grants or low-interest, long-term repayment loans.

The Department of Water Resources published the results of the survey on March 22, 1977, in a report entitled "Preliminary Findings of the Mail Questionnaire Survey to Ascertain Effects of the 1976-77 Drought on Dairy Farmers and Ranchers in Marin County". This report provided public agencies with a reliable assessment of the farm water supply situation and helped secure federal assistance and additional county aid.

The first water hauling program was funded half by the ranchers and half by the County. No federal funds were used. However, extensive federal assistance was received for the second phase of the hauling program, which began April 27, 1977, and did not terminate until January 1978, following drought-breaking



rains. The federal funds were received through the U. S. Department of Labor's Comprehensive Employment Training Act (CETA) and were used primarily to pay for the truck drivers. At least six trucks were hauling water 7 days a week working two shifts a day.

At the peak of the water hauling program in mid-November 1977, 1 320 cubic metres (350,000 gallons) daily were being hauled to 53 ranchers and 16 domestic users; a county contribution of \$45,000 a month was required to operate the program.

The expenditures and the contributions made by the Federal Government, the County, and the ranchers to the two emergency water hauling programs were as follows:

Federal	171,822.64	-	37.4%
County	248,459.81	-	53.9%
Ranchers	37,553.90	-	8.2%
Private			
Donations	2,500.000	-	0.5%
	<hr/>		<hr/>
	\$460,336.35		100.0%

The \$460,000 was for water hauling costs only. The ranchers paid in an additional \$24,000 for the water itself.

#### Water Deliveries During the Drought

The amount of water delivered to ranchers in west Marin during the drought has been conservatively estimated at 155 000

cubic metres (41 million gallons) supplied by the North Marin County Water District and the City of Petaluma Water Department. In September 1977 alone, these two agencies supplied more than 20 000 cubic metres (5.5 million gallons) to ranchers. Water was supplied during the drought not only to water-short ranchers and residents in west Marin but also to residents and businesses in the rationed service area of MMWD.

#### Federal Programs of Assistance to Ranchers

In conjunction with the county water hauling program, ranchers impacted by the drought were greatly assisted by special drought relief programs of the Federal Government.

The Emergency Livestock Feed Program, administered by the Agricultural Stabilization and Conservation Service, made grants of \$901,860 to 120 ranchers in Marin County to assist in paying for livestock fodder purchased during the drought. In addition, 34 ranchers received grants totalling \$57,683 from the Drought, Flood and Conservation Program authorized May 4, 1977, to improve water supply on their ranches. Grants were made for drilling wells, developing springs, water piping, and water troughs, and in a few instances for enlarging and constructing dams.

The Farmers Home Administration advised the Department in the spring of 1979 that Marin County ranchers were continuing to apply for matching grant funds to drill wells and build dams under the Administration's regular conservation program.





## CHAPTER 7. AFTERMATH OF THE DROUGHT

Water conservation, an unrealized ethic before the drought in Marin County, became a necessity during the drought, and has now evidently become a continuing reality. The mandatory rationing, pricing measures, and intensive conservation program employed by MMWD during the drought were highly effective, reducing community water consumption by 63 percent.

The effects of these measures obviously persist, because the return to normal water conditions in 1978 did not bring a return to predrought water use. Water use in 1978 was still down 35 percent and indications are that future annual water consumption will continue at a level somewhere well below predrought days. Water use in MMWD from November 1, 1978, through July 1979 indicates that consumption in 1979 will be around 25 percent below predrought use.

These reduced rates of use following the drought were somewhat of a surprise to MMWD. The District anticipated that consumption in 1978 would be reduced overall about 20 percent, primarily as a result of plumbing changes made during the drought. Budgets drawn up in early 1978 were based on a possible water consumption reduction of 25 percent in the first half of 1978 and 15 percent in the second half. When water use stayed well below those estimates, so of course did revenues, and MMWD found itself in a pinch between lowered revenues, mounting costs, and the desire to continue saving water.

The result is that the drought has forced a complete reanalysis of the water picture in Marin County. Water conservation is now an integral part of water demand projections and facilities planning for MMWD and the North Marin County Water District, the County's two largest water utilities.

### Continuing Water Conservation in Marin County

With a 35 percent reduction in use in 1978 and an apparent 25 percent reduction in 1979, Marin water users are demonstrating that water conservation can be a way of life. Many water-saving techniques and devices employed both indoors and outdoors during the drought are still in use, saving water, energy, and money with very little expense or inconvenience on the part of the consumer.

#### Indoor Water Conservation

While graywater use has largely been dispensed with, many households still practice a wide variety of conservation measures. MMWD estimates that more than 80 percent of households and firms are using the water-conserving devices--low flow shower heads, flow restrictors, toilet tank plastic bottles--that were issued free by the District during the drought. Many households are also using shower shutoff valves, which allow users to turn off water for lathering without a temperature readjustment (a 25 percent water and energy saver); faucet aerators, which reduce water use by 10 percent; and insulated hot water pipes, which help eliminate heat loss. Tissues and cigarette butts are thrown in the trash rather than flushed down the toilet. Shavers fill the sink with water rather than leave the tap running, using 3.8 litres (1 gallon) of water instead of 19 litres (5 gallons).

#### Outdoor Water Conservation

Gutter flooding is a thing of the past. Community attitudes, peer pressure, reinforce the abolition of gutter flooding and the washing of sidewalks and pavements by hosing. Cars and boats are seldom washed with a running hose. Detection and quick remedy of water leaks

is a prevailing practice in household and distribution systems.

Outdoor watering devices are also in widespread use and include automatic pistol grip shut off hose nozzles, secure hose connections with washers in good repair, inexpensive timers that automatically shut off hoses, drip irrigation equipment for shrubs and ground covers, and root feed irrigators for deep watering and fertilizing of shrubs and plants.

Landscapes are not irrigated as much as they used to be. There has been a dramatic trend away from sprinkling lawns during the day when evaporation rates are high. Sprinkling occurs in the early morning and evening, with timed automatic sprinkling becoming popular. Also, the community has been slow to replace lawns that died out during the drought. There is an increasing trend to drought-tolerant plants in combination with rock, gravel, and tanbark in place of former grassed areas. Small lawns strategically placed for effect have in some instances replaced previously expansive lawns.

At the end of the summer of 1978, many brown lawns were still evident. Tardiness to replant lawns has been attributed at least partly to a "wait and see" attitude regarding the 1979 water supply. In any event, brown lawns are no longer as socially irresponsible as they once were and detract little if any from the sale price of a house in Marin County.

#### Water Conservation by Businesses

The various conservation measures, mainly plumbing alterations, taken during the drought by restaurants, car washes, laundries, motels, business offices, and public agencies contributed to the reduction in water consumption in 1978. Water is still not served in restaurants, unless requested. The retrofitting and replumbing of dishwashing equipment in restaurants and of clothes washing equipment in laundries doubtless remain in operation. Vehicles are not washed as frequently and not as much water is used in each washing.

A strict reading of water consumption indicates that businesses, like resi-





dents, are still conserving water. However, the extent to which each sector has been retrofitted to save water and how present water use practices are likely to affect future water demands can be ascertained only by a survey of different business establishments and residents. The households, firms, and public agencies responding to DWR's questionnaire in March 1977 have not been resurveyed, but a resurvey at some later date would provide valuable additional insight into the continuation of a community's drought consciousness.

### Water Wells

Drilling a new well is not a water conservation measure as such, but ground water from individual wells does reduce demands on the water utilities. Ground water in Marin County is not a major source of supply. Nonwaterbearing rock underlies most of the county, and as a result ground water supplies are spotty and quantities generally low. Many successful wells have been drilled in Marin County, but the incidence of dry holes is high.

During the drought, a number of residents, the City of San Rafael, and two large high schools drilled wells and watered lawns and gardens, city parks, and playgrounds with new-found ground water. Drilling of new wells is still going on in MMWD's service area, although the rate has greatly declined since the drought. MMWD estimates that 1 234 cubic dekametres (1,000 acre-feet) is supplied by these substitute sources and that ground water users will continue to use these wells for summer watering of landscapes while the water is available and the plumbing and irrigation systems remain operative. It is currently cheaper to remain on a home ground water supply than to use MMWD water at 83 cents per 2.83 cubic metres (100 cubic feet).

The City of San Rafael will continue to use the wells it drilled during the drought to water five city parks. Its capital investment in wells, pumps, and

irrigation equipment of \$183,000 will be recovered in 5 years from savings in water costs. As the price of MMWD's water rises in the future, large residential irrigators and establishments in the service and public sectors may develop ground water supplies wherever feasible. Substitution of a water source, a vital measure taken during the drought to offset MMWD's critically short supply, is now working to reduce MMWD's summer water sales and contributing to the present cost-revenue squeeze for the District.

### Cost and Revenues

MMWD got caught in a cost-revenue squeeze following the drought. Operating costs were up because of inflation and the expense of continuing water conservation measures, among other things, and revenues were down because water rates had been dropped back from the high drought-days charge, water use was still surprisingly low in spite of the good water supply, and people were drawing on their "water bank account", credits they had accumulated in 1977 by using less than their allotments. In 1978, when water was plentiful, users were rewarded for their thrift by getting water at a discount rate. The water bank program was a very effective drought measure, but it added to the district's revenue problems when the drought was over.

### Cost Reduction

The reduced rate of water use has itself saved money. In 1978, with water consumption running 35 percent below pre-drought levels, MMWD's electrical energy requirement for treatment and distribution of water was down 37 percent -- a total of 1,300,000 kilowatt hours -- sufficient energy to supply 220 Marin homes for a year. Reduced consumption, if it stays reduced, also means that MMWD can defer the construction of expensive additional facilities for future water supply, a deferral of an investment exceeding \$11 million (1978 dollars). This estimate is based on the assumption that conservation allows a deferral of



7 154 cubic dekametres (5,800 acre-feet) of water supply and that amount will involve a capital outlay equivalent to that required to raise Kent Lake -- a water supply alternative under active consideration by MMWD.

However, to take full advantage of the opportunity to reduce costs, the district has to reappraise not only the day-to-day operations but also the total system of charging fees for the many public services provided by the utility in serving water to its customers. Connecting water to the service outlet, turning off a water service, and the detection and repair of household water leaks are but a few of these services.

### Service Fees

In the future, the service fee structure may undergo changes in order to better reflect actual costs. In the past, the charge for a service was a nominal or standard fee or the service was free to the individual customer; the costs of such services were spread over all users. In some cases, service such as a water connection is quite costly, involving considerable engineering time. A fee of \$3 is charged to turn off a water service but the actual cost to MMWD is about \$13. In the future, the costs of these services will not be lumped into the costs of operating the utility. Customers will pay the full costs for the particular service they are provided.

Insofar as water conservation is concerned, it is expected that the new scheme of charging fees will have varying effects. Charging the actual cost of a connection to a customer could tend to dampen the rate of water connections and be conservation-inducing, while a fee for household leak detection and repair would work counter to water conservation.

In addition to overhauling the schedule of fees for services, MMWD is also assessing the efficacy of various water pricing schemes.

### Pricing

It is not only for these reasons MMWD must patiently and cautiously ponder whether and how much to increase the price of water. After all, the community has demonstrated an amazing ability to reduce its water consumption drastically. There is no certainty that raising the price will bring in the sought increment in revenue. It is a volatile situation where a price increase could more than proportionally decrease the total quantity of water demanded. Consequently, revenue might fall short of the expected gain, remain the same, or even decline.

Doubtless a price hike would reinforce a tendency for relatively heavy water users, such as cities, schools, golf courses, prisons, hospitals, restaurants, and other service establishments, to restrict water consumption still further. The effect upon revenue of raising price is simply not known for each of the different classes of water users. The efficacy of a price increase as well as a change in the present pricing system is now being closely studied with the objective of relieving the revenue pinch.

Revenue is derived from the quantity of water consumed by users, multiplied by unit-price which now stands at 83 cents per 2.8 cubic metres (100 cubic feet). MMWD's prerogative to raise the unit price is tempered by the realization that MMWD's price is the highest in the San Francisco Bay Area. To raise the price could be extremely unpopular, if not politically infeasible, in a community aware that water sells for 47 cents per 2.8 cubic metres (100 cubic feet) in San Francisco. Besides, raising the price of water is difficult to explain

when once drought-emptied reservoirs are now brimming over.

### Future Water Demand and Supply

The drought and the conservation measures taken to counter it not only affect present demands for water in the District but also serve as factors in shaping future water supply plans and projections of future demands.

As a result of the drought, MMWD in planning future supply had first to recalculate the net safe yield of its existing water supply, which comes from the runoff into five reservoirs, plus the Soulejule Reservoir and the intertie with the North Marin County Water District. Net safe yield is usually defined as the amount of water that can be drawn from a source over a long period of time without totally depleting the storage. Previous rainfall and/or runoff records over long periods of time, including dry cycles, are the basis for estimating net safe yield.

The net safe yield of MMWD's supply was estimated to be 43 173 cubic dekametres (35,000 acre-feet) prior to the drought. This yield, however, dropped to 32 318 cubic dekametres (26,200 acre-feet) annually when runoff for the drought years of 1976 and 1977 entered the calculations. Up to the time of the drought, the supply then existing was projected to provide for MMWD water needs until 1995. Predrought annual water demand was 39 719 cubic dekametres (32,200 acre-feet).

MMWD's plan for future water supply management illustrates that while conservation and waste water reclamation are significant elements in the demand-supply picture, additional sources have to be developed if water demands projected to the year 2000 are to be satisfied. Conservation does delay the ini-

tiation of water supply projects with substantial savings in capital and debt servicing costs. But, in a district with expanding water demands, conservation doesn't eliminate the eventual need for additional sources of supply even though some in the community may still feel that conservation and waste water reclamation will be adequate to satisfy future demands. In general, the community is now more informed on water issues; the majority of users have voted for bond issues that allow MMWD to plan for the development of additional sources. The feeling now apparently is that even with conservation and waste water reclamation, new water supplies are necessary if only to avoid or reduce the degree of inconvenience and hardship that could result from another drought as severe as the one in 1976-77.

MMWD proposes to increase its water supply by:

1. Negotiating for 5 300 cubic dekametres (4,300 acre-feet) of storage capacity in Warm Springs Dam on the Russian River to permit near-capacity use of the existing intertie with the North Marin County Water District. The intertie has a delivery capability of 6 168 cubic dekametres (5,000 acre-feet). Existing agreements and facilities allowed an average delivery of 3 577 cubic dekametres (2,900 acre-feet) during the 1975-77 drought. The proposal to buy storage capacity in Warm Springs means an increased yield of 1 727 cubic dekametres (1,400 acre-feet).
2. Raising Peters Dam by 14 metres (45 feet) to increase storage in Kent Lake 19 736 cubic dekametres (16,000 acre-feet) to give increased net safe yield of 6 168 cubic dekametres (5,000 acre-feet), with 987 cubic dekametres (800 acre-feet) of that for stream release during dry weather to enhance fish and wildlife.

MMWD's water demand and supply picture for the year 2000 is projected as follows:

Demand			Supply
In cubic dekametres (acre-feet)			
Projected	48 107 (39,000)	Present net safe yield (reservoirs and intertie)	32 318 (26,200)
"Cushion"	3 700 (3,000)	Conservation and new development	2 097 (1,700)
		Conservation carryover	6 291 (5,100)
		Waste water reclamation	2 467 (2,000)
		Increment in Russian River supply	1 727 (1,400)
		Increment in Kent Reservoir supply	5 181 (4,200)
		Phoenix-Bon Tempe Transfer Project (in construction)	493 (400)
	<hr/> 51 807 (42,000)		<hr/> 51 810 (42,000)

Present supply including the Phoenix-Bon Tempe transfer project under construction amounts to 32 811 cubic dekametres (26,600 acre-feet). An additional 18 996 cubic dekametres (51,400 acre-feet) therefore is required to match projected demand, including the cushion of 3 700 cubic dekametres (3,000 acre-feet). Of the 18 936 cubic dekametres (15,400 acre-feet) required to meet projected demands in the year 2000, conservation, leak detection, and waste water reclamation constitute 12 088 cubic dekametres (9,800 acre-feet), or 63 percent.

The water demand-supply situation projected for year 2000 employs "best estimates" of attainable future water conservation and the consumption levels

that are likely to endure. In addition to the projected demand for the year 2000 of 48 107 cubic dekametres (39,000 acre-feet), the Board of Directors of MMWD has added 3 700 cubic dekametres (3,000 acre-feet) as a "cushion" -- a margin of safety to minimize future rationing in the event of a severe drought and in case conservation and waste water reclamation do not reach their expected goals set out above.

#### Factors Obscuring Emergent Water Demands

In any major water study, the projection of future water demand is a first crucial step. And as is clear from MMWD's attempt to predict demand and the ultimate levels of conservation, several



imponderables are complicating the predictions.

The Future Mix of Residential, Light Industrial, and Public Uses. Although consumption by the residential sector dominates the total consumption picture, three other sectors -- the commercial, industrial, and public use sectors -- are significant water users, and each is not immune to the evolving pattern and density of commercial and residential areas.<sup>1/</sup> Although the expansion and proliferation of new residential areas is limited in MMWD's service area, the impact of changing income and rising prices for water and energy in the future still have to be reckoned with in any objective appraisal of future water consumption.

Aside from the promotion of conservation, several influences in the service area point to eventual permanent reduction of both public water use and residential water use. Per capita use might be presumed to decline from the predrought level of 662 litres (175 gallons) daily as a result of:

1. General changes in family size and age.
2. Increased incidence of apartment and condominium living.
3. Smaller lot sizes.
4. Increasing efficiency of water-using appliances, especially the technologies of water use and waste water reuse adopted by commercial and industrial customers.

5. More efficient (water-saving) landscape irrigation.

6. The efficiency of the pricing incentive, aided by the increase in future energy costs to firms and households.

Rate of Population Growth. The difficulty in predicting the population to be served water is reflected in the variation in recent projections. In 1973, the Marin County Planning Department estimated the year 2000 population of MMWD's service area to be 214,800. In 1976, MMWD, which was then doing its own estimating, projected a year 2000 population of 249,000. Since the drought, MMWD is basing its water demands on the growth projections of the Planning Department, which now forecasts 199,000 people in MMWD's service area by the year 2000, living in 79,550 dwelling units with a household size of 2.5 persons. By 2000, a total water supply of 48 107 cubic dekametres (39,000 acre-feet) will be required to match projected water demands for a population of this size consuming 662 litres (175 gallons) per capita per day. Illustrative of the problems of projection is the fact that while the Planning Department's population estimates have gone down in recent years, the number of new housing units is in line with its 1973 countywide plan.

Given the uncertainty of many of the factors that make up water demand, estimating near-future water consumption, let alone that of year 2000, is a difficult task at this time in Marin County. MMWD feels that two or more years of water use experience will be required before a reliable assessment of future water demands can be made.

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<sup>1/</sup> While there are no industries in MMWD's service area that can be classified as heavy water users, the commercial and service sectors contain many different users which the drought and water rationing has shown to be especially adept at reducing water consumption. The commercial and service sectors include such establishments as primary and secondary schools, colleges, hospitals, nursing homes, hotels and motels, office buildings, department stores, shopping centers, car washes, service stations, laundries, restaurants, clubs, churches, and barber and beauty shops. Public uses included water used for fire protection, street cleaning, irrigation for public parks, and water use in publicly owned buildings.



## BIBLIOGRAPHY OF DROUGHT-RELATED INFORMATION

### A. DWR's Drought-related Reports

- *An Urban Water Conservation Conference - Proceedings.*  
January 1976.
- *Special Report on Dry Year Impacts in California.*  
February 1976.
- *Water Conservation in California.* Bulletin 198.  
May 1976.
- *The California Drought - 1976.* May 1976.
- *The California Drought - 1977, An Update.*  
February 19, 1977.
- *The Sacramento Valley Water Use Survey (1976).*  
June 1977.
- *Water Conditions and Flood Events in California.*  
Bulletin 202-76. July 1977.
- *The Continuing California Drought.* August 1977.
- *Operational Criteria for the State Water Project -*  
*December 1, 1977 - December 31, 1978.* December 1977.
- *California Water.* Bulletin 201-77. February 1978.
- *Water Conditions in California.* Bulletin 120-76. (This  
bulletin is released in February, March, April, and  
May of each year.)
- *Water Conditions in California.* Bulletin 120-77.
- *Water Conditions in California.* Bulletin 120-78.
- *The 1977 California Summer Rain Enhancement Program.*  
May 1978 (By Dr. Pierre St.-Amand and Mr. Jerry R.  
Ennis for DWR).
- *The California Drought, A Review.* May 1978.
- *Water Conditions and Flood Events in California.*  
Bulletin 202-77. September 1978.
- *The Sacramento Valley Water Use Survey - 1977.*  
Bulletin 168. October 1978.



- *A Pilot Water Conservation Program. Bulletin 191. October 1978.*

Appendix A: *San Diego Metropolitan Area. March 1978.*  
 Appendix B: *Santa Cruz County. March 1978.*  
 Appendix C: *City of Sanger. March 1978.*  
 Appendix D: *El Dorado Irrigation District. March 1978.*  
 Appendix E: *City of El Segundo. March 1978.*  
 Appendix F: *Community of Oak Park. March 1978.*  
 Appendix G: *Device Testing. March 1978.*  
 Appendix H: *Device Selection. March 1978.*

- *State Agency Efforts in Water Conservation. Memorandum Report on ACR 165. December 1978.*

- *California Water. Bulletin 201-78. April 1979.*

- *A Catalog of Drought-Resistant Plants. Bulletin 209. September 1979.*

B. Leaflets (Prepared by DWR or jointly with other agencies)

- *Model Ordinances Prohibiting Nonessential Uses of Water.*
- *Model Ordinances Allocating Water.*
- *Summaries of Various California Communities' Ordinances.*
- *Water Pricing.*
- *Using Household Waste Water on Plants.*
- *Saving Water in Landscape Irrigation.*
- *Home Landscaping.*
- *Common Misconceptions about the California Drought Tolerant Landscaping.*
- *Water-Conserving Vegetable Gardening.*
- *Drought Garden Plant List.*
- *Guide to the Model Urban Conservation Garden.*
- *Toilet Damming Devices.*
- *Toilet Flush Adapters.*
- *Low Flush Toilets.*
- *WC<sup>2</sup> - Water Conservation in the Water Closet.*

- *Automatic Clothes Washers.*
- *Automatic Dishwashers.*
- *Faucet Flow Controls.*
- *Low Volume Shower Heads and Adapters.*
- *Hints for Home Improvements.*
- *Swimming Pool Fact Sheet.*
- *Water Wells ... And What You Should Know About Them.*
- *Hints for Water Conservation.*
- *Are You Using Gray Water During The Drought?*
- *Save Every Last Drop.*
- *Save Water.*
- *Water Conservation.*
- *A Selection of Water Conservation Program Aids.*
- *Water Awareness Program 1978-79.*

C. Booklets for Schools (Although drought-related, this is a continuing conservation program)

- *Captain Hydro.*
- *Captain Tlaloc.*
- *Captain Hydro Teacher's Guide.*
- *Water Play.*
- *Water Play Teacher's Guide.*
- *Teacher's Guide Supplements:*

*Region 1 -- North Coastal*

*Region 2 -- North Lahontan, Sacramento Basin  
Delta-Central Sierra*

*Region 3 -- San Francisco Bay Area*

*Region 4 -- San Joaquin, Tulare Basin*

*Region 5 -- Central Coastal*

*Region 6 -- South Coastal*

*Region 7 -- South Lahontan, Colorado Desert*

#### D. Drought Tips

- *Reducing Evaporation from Farm Ponds and Reservoirs, #1.*
- *Reducing Evaporation from Farm Ponds and Reservoirs, #2.*
- *Tips for Stretching Water on Pasture and Range.*
- *Tips for Stretching Water on Crops and Soils.*
- *Tips for Stretching Water on Yards and Gardens.*
- *Tips for Stretching Irrigation Water.*
- *The Use of Treated Waste Water.*
- *Vertebrate Animal Damage: Possible Effects of Drought.*
- *Common Irrigation Problems -- Some Solutions.*
- *Crop Salinity Tolerance.*
- *Guidelines for Reactivating Unused Wells.*
- *Water Management.*
- *How Much Irrigation Water Are You Applying?*
- *Irrigation -- When and How Much?*
- *Selecting an Irrigation System--Should You Change?*
- *Crop Water Use (Distributed by Interagency Agricultural Information Task Force).*
- *Sacramento Valley, Vegetable Crops -- Tomatoes.*
- *Sacramento Valley, Tree Crops and Vines.*
- *Sacramento Valley, Field Crops.*
- *San Joaquin-Sacramento Delta, Vegetable Crops.*
- *San Joaquin-Sacramento Delta, Tree Crops and Vines.*
- *San Joaquin-Sacramento Delta, Field Crops.*
- *San Joaquin Valley, Vegetable Crops.*
- *San Joaquin Valley, Tree Crops and Vines.*
- *San Joaquin Valley, Field Crops.*



- ° *South Coastal Plains, Vegetable Crops.*
- ° *South Coastal Plains, Pasture and Trees.*
- ° *Central Coastal Plains, Vegetable Crops.*
- ° *Central Coastal Plains, Trees.*
- ° *Central Coastal Plains, Field Crops.*
- ° *Central Coastal Interior Valleys, Vegetable Crops.*
- ° *Central Coastal Interior Valleys, Field Crops, Trees and Vines.*

E. Published Papers

- ° "California's Program for Dealing with the Drought".  
Ronald B. Robie. *Journal, American Water Works Association.*  
February 1978.

F. Leaflets Distributed by the Drought Information Center

- ° *Drought Information Bulletin - #1 (1/17/77), #2 (2/1/77), #3 (2/7/77), #4 (2/14/77), #5 (2/18/77), #6 (2/22/77), #7 (2/22/77), #8 (3/7/77), #9 (3/14/77), #10 (3/21/77), #11 (3/28/77), #12 (4/4/77), #13 (4/11/77), #14 (4/18/77), #16 (4/25/77), #18 (5/19/77), #20 (5/23/77), #22 (6/6/77), #24 (6/20/77), #26 (7/11/77), #28 (8/8/77), #30 (9/6/77), #32 (10/3/77), #33 (11/1/77), #34 (12/13/77), #35 (12/20/77), #36 (12/27/77), #37 (1/3/78), #38 (1/10/78).*
- ° *Drought Information Bulletin - Recreation Report - #15 (4/8/77), #17 (5/2/77), #19 (5/16/77), #21 (5/31/77), #23 (6/23/77), #25 (6/27/77), #27 (8/1/77), #29 (8/29/77), #31 (8/19/77).*
- ° *River Flow Data for Boaters - (6/13/77), (7/18/77), (8/15/77).*

G. Publications Prepared Jointly with Other Agencies

- ° *Agricultural Water Conservation Conference - Proceedings.*  
June 23-24, 1976. U. S. Cooperative Extension Service.
- ° *Proceedings of the Governor's Drought Conference.* March 1977. Department of Food and Agriculture.
- ° *Drought, Alternative Strategies for 1978.* Governor's Drought Emergency Task Force.
- ° *Industrial Water Allocation and Conservation in California.* January 1978. Office of Emergency Services, California Manufacturing Association.

- *Guide to the Model Urban Water Conservation Garden. Office of Appropriate Technology.*

H. Papers Distributed by Interagency Agricultural Information Task Force

- *Bureau of Reclamation Contractors - 1977 Available Water Supply.*
- *State Water Project - Currently Scheduled 1977 Deliveries of Project Water.*
- *Critical Periods of Water Need in the Production of Fruit and Nut Crops.*
- *Critical Growth Stages of Field Crops as Related to Managing Limited Water Supplies.*
- *Conservation Irrigation of Field Crops: A Drought Year Strategy.*
- *Water Measurement.*















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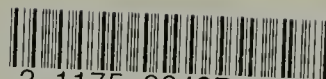
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